ASTRONOMY

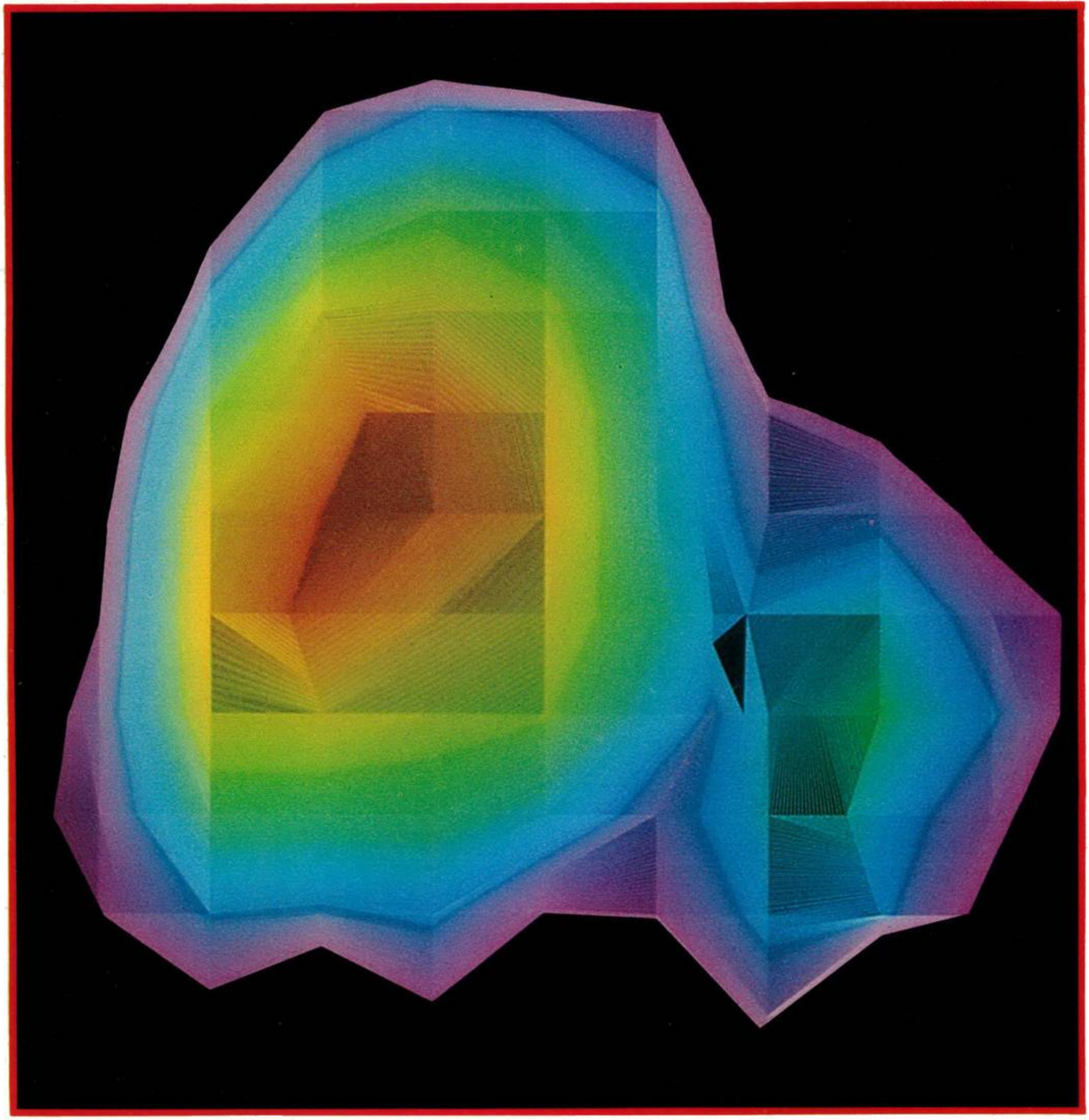
November 1982
U.S. $2
UK £1
Can. $2.25

Inside the Quasars

The Hidden Mass of Galaxies

Binoculars: Choosing and Using Them

ICD# 08070 71574



3C 273 — Faster than Light?

5 Basic Reasons Your Schmidt-Cassegrain Telescope Has to be a Meade:

1—True worm-gear, photographic-precision drive systems on all models—So smooth, so accurate that **100% off-the-shelf** 8″ Meade 2080's were used for **every** astrophoto shown on these pages. Competing Schmidt-Cassegrain manufacturers place their 8″ tube assemblies onto custom worm-gear mounts to obtain most long exposure photos they publish; we don't need to.

2—Aperture-for-aperture, the brightest images obtainable—Exclusive Meade oversize primary mirrors, combined with the only optimized baffle systems in the industry, yield off-center star images 10% brighter than competing 8″ Schmidt-Cassegrains. Incredibly, the 8″ Meade 2080 **without** high transmission coatings yields brighter off-center images than competing 8″ telescopes **with** coatings! The Meade 10″ Model 2120 yields off-center images almost as bright as competing 11″ models, and at about 60% of the price.

3—Diffraction-limited optics—Ultrasmooth optical surfaces polished to accuracies within 1/10-wave or better. Each 3-element set is **individually** hand-matched to produce a knife-edge optical null and razor-straight bands under the Ronchi test. **Meade Schmidt-Cassegrain optics are the most thoroughly tested of any manufacturer's and are the finest obtainable in any commercial telescope, bar none.**

4—The most stable tripod/wedge systems available—The Meade Variable-Height Field Tripod for the 8″ Model 2080 and 10″ Model 2120 makes competing tripods look thin and weak by comparison. And you'll appreciate the extremely low damping time of the Meade Field Tripod—suitable both for visual and sensitive astrophotographic applications.

5—1980's technology and quality control—Competing Schmidt-Cassegrains designed in the 1960's have been made virtually obsolete by these modern Meade optical and mechanical designs. Little wonder that Meade Instruments is now the World's fastest-growing manufacturer of modern astronomical instruments.

Prices: Meade 4″, 8″ and 10″ Schmidt-Cassegrain models are very competitively priced. In the U.S.A. and Canada contact your mail-order or local Meade showroom dealer for his best prices.

52-Page General Catalog 82-C: $3.00 (Outside North America $5.00 for air mail.) Full-color Schmidt-Cassegrain Astrophoto Brochure included free with each catalog.

Meade Bulletin 800: "A Frank Technical Comparison of Commercially Available Schmidt-Cassegrains," free for the asking.

Telescopes Shown: *(top) Meade 8″ Model 2080 with optional photographic systems, including 4″ Schmidt-Cassegrain Photo-Guide Telescope; and (bottom) Meade 10″ Model 2120 with optional 2″ f/12 Photo-Guide Telescope.*

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, California 92626
Phone (714) 556-2291

AUTHORIZED INTERNATIONAL DISTRIBUTORS

France
Devaux Chevet S.A.
35, Rue de Rivoli
75004 Paris, France

Medas S.A.
57, Avenue Prés. Doumer
B.P. 181
03206 Vichy, France

Switzerland
E. Aeppli/Spiegeloptiken
Loowiesenstrasse 60
CH-8106 Adlikon
Switzerland

Italy
Ottica Miotti
Corso XXII Marzo, 32
20135 Milan, Italy

Japan
MIC International Corp.
Hoshino Bldg.
7-20, Toranomon, 3-chome
Minato-ku, Tokyo, 105 Japan

West Germany, Austria
Kosmos Service-71
Postfach 640, Pfizerstrasse 5-7
7000 Stuttgart 1
West Germany

Australia
Scope Services Australia
5 Packers Drive
Highbury, Adelaide
South Australia 5089

Science World
363 Cambridge Street
Wembley, 6014, Perth
Western Australia

Spain
IMVO/R. Roure Codoñer
C/Col. Legi n. 24
(Bordeta) Lleida, Spain

Alcot Instrumentos
Dr. Esquerdo, 114-4° D
Madrid-30, Spain

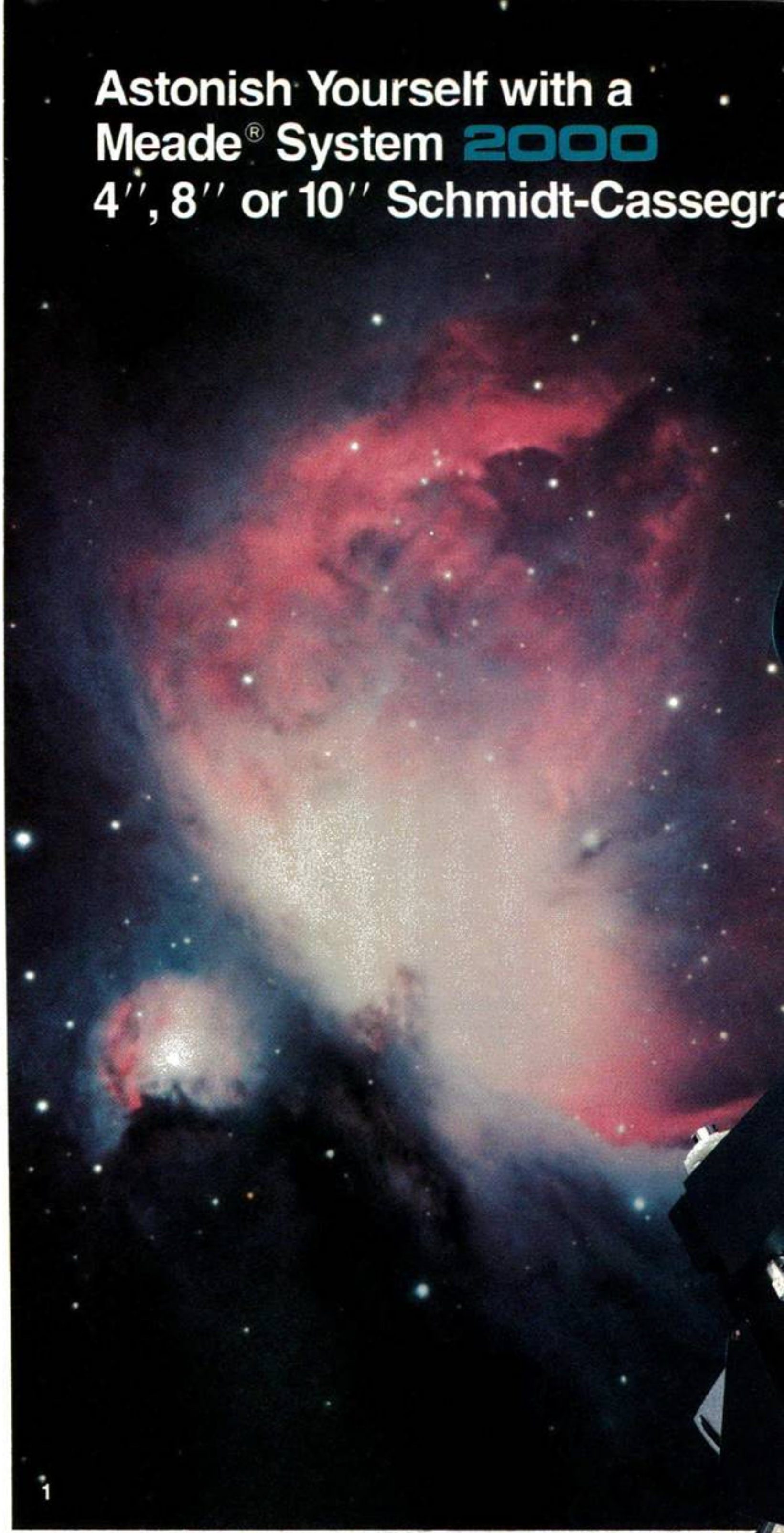
Sweden, Denmark, Norway
AB G Wendelholm
Box 14069 S-10440
Stockholm, Sweden

Taiwan
B & E Optical Co., Ltd.
P.O. Box 84-621
Taipei, Taiwan

New Zealand
City Associates, Ltd.
6 Normanby Rd.
Auckland, New Zealand

Portugal
Contabilex
Av. 25 de Abril, 13-1°
2750 Cascais
Portugal

Belgium, Netherlands
O.P.-Slotte
Chaussée D'Alsemberg 59
1060 Brussels, Belgium



Astonish Yourself with a Meade® System 2000 4″, 8″ or 10″ Schmidt-Cassegra

1

2

8″
Model 2080
4
5
NEW 10″
Model 2120
3

6

7

8

9

All astrophotographs shown on these pages were taken through off-the-shelf, unmodified Meade 8″ Model 2080 Schmidt-Cassegrain telescopes. For further technical details on these and many other astronomical photographs, send for your free copy of the Meade Schmidt-Cassegrain Astrophoto Brochure. (Alternately, the complete Meade 52-page General Catalog is available at $3.00 by First Class Mail and includes the Astrophoto Brochure at no additional charge.)

Key to Photographs
1, 2, 3, 5, 7 — Leo Henzl; 4, 6, 8 — Emery Hildebrand;
9 — John Sanford

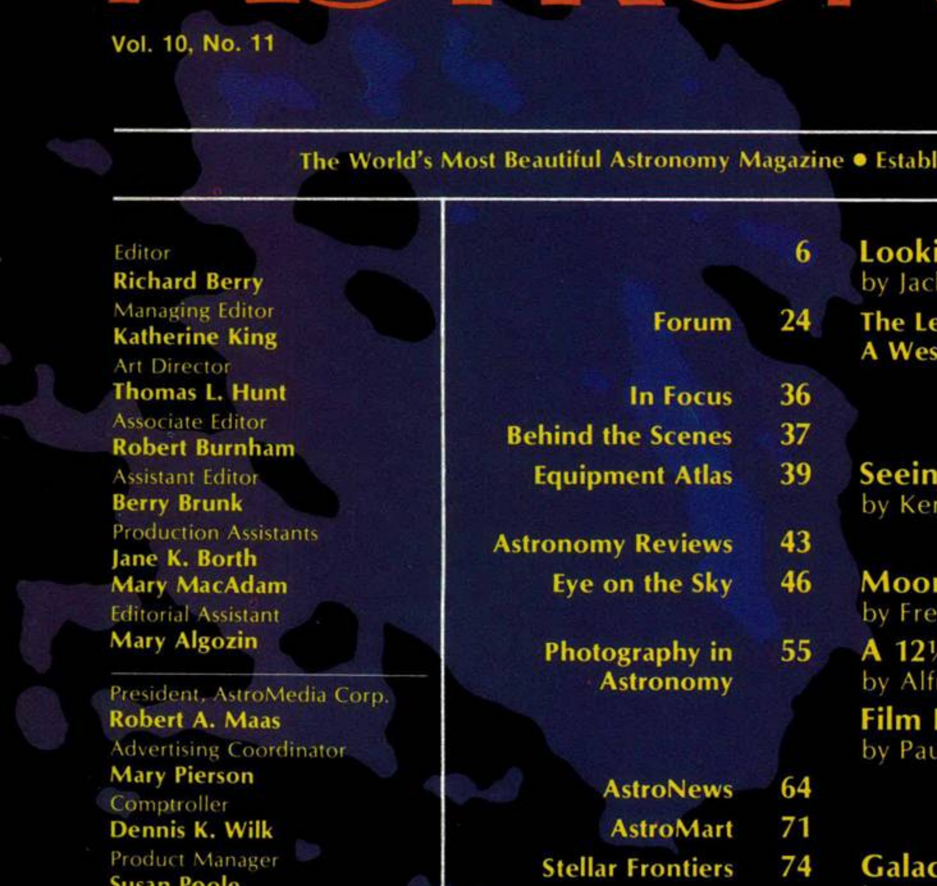
1. Orion Nebula M42; exposure time 50 mins. **2.** Andromeda Galaxy M31; 60 mins. **3.** Galaxy M82; 60 mins. **4.** Milky Way in Sagittarius (50mm piggyback photo). **5.** Spiral Galaxy M33; 75 mins. **6.** Spiral Galaxy M51; 60 mins. **7.** Galaxy NGC 253; 40 mins. **8.** Omega Nebula M17; 40 mins.; **9.** Moon — Clavius region; 1-sec.

ASTRONOMY

Vol. 10, No. 11

November 1982

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther



6 **Looking Inside Quasars**
by Jack Schendel

Forum 24 **The League Meets in Peoria**
A Westerbork Decade

In Focus 36

Behind the Scenes 37

Equipment Atlas 39 **Seeing Double**
by Ken Hulme

Astronomy Reviews 43

Eye on the Sky 46 **Moon Occults Mars**
by Fred Schaaf

Photography in Astronomy 55 **A 12½-inch Ritchey-Chretien**
by Alfred Lilge
Film Loading Tips
by Paul Roques

AstroNews 64

AstroMart 71

Stellar Frontiers 74 **Galactic Coronas**
by Laurence Marschall

Gazer's Gazette 82 **21 Objects for Binocular Observers**
by Brian Jones

The Backyard Astronomer 87 **Andromeda**

Cover: At ultra-high resolution with today's most powerful radio telescopes, the quasar 3C-273 shows a central core and a small knot in the jet. The knot appears to be moving away from 3C-273 at nearly ten times the speed of light, in complete defiance of Einsteinian physics. These pages: On a larger scale, the jet of nearby radio galaxy M-87 breaks into a succession of knots before broadening into large diffuse lobes of radio emission.

Editor
Richard Berry
Managing Editor
Katherine King
Art Director
Thomas L. Hunt
Associate Editor
Robert Burnham
Assistant Editor
Berry Brunk
Production Assistants
Jane K. Borth
Mary MacAdam
Editorial Assistant
Mary Algozin

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Mary Pierson
Comptroller
Dennis K. Wilk
Product Manager
Susan Poole
Circulation Director
Carol Adams
Circulation Manager
Rosemary L. Pickart

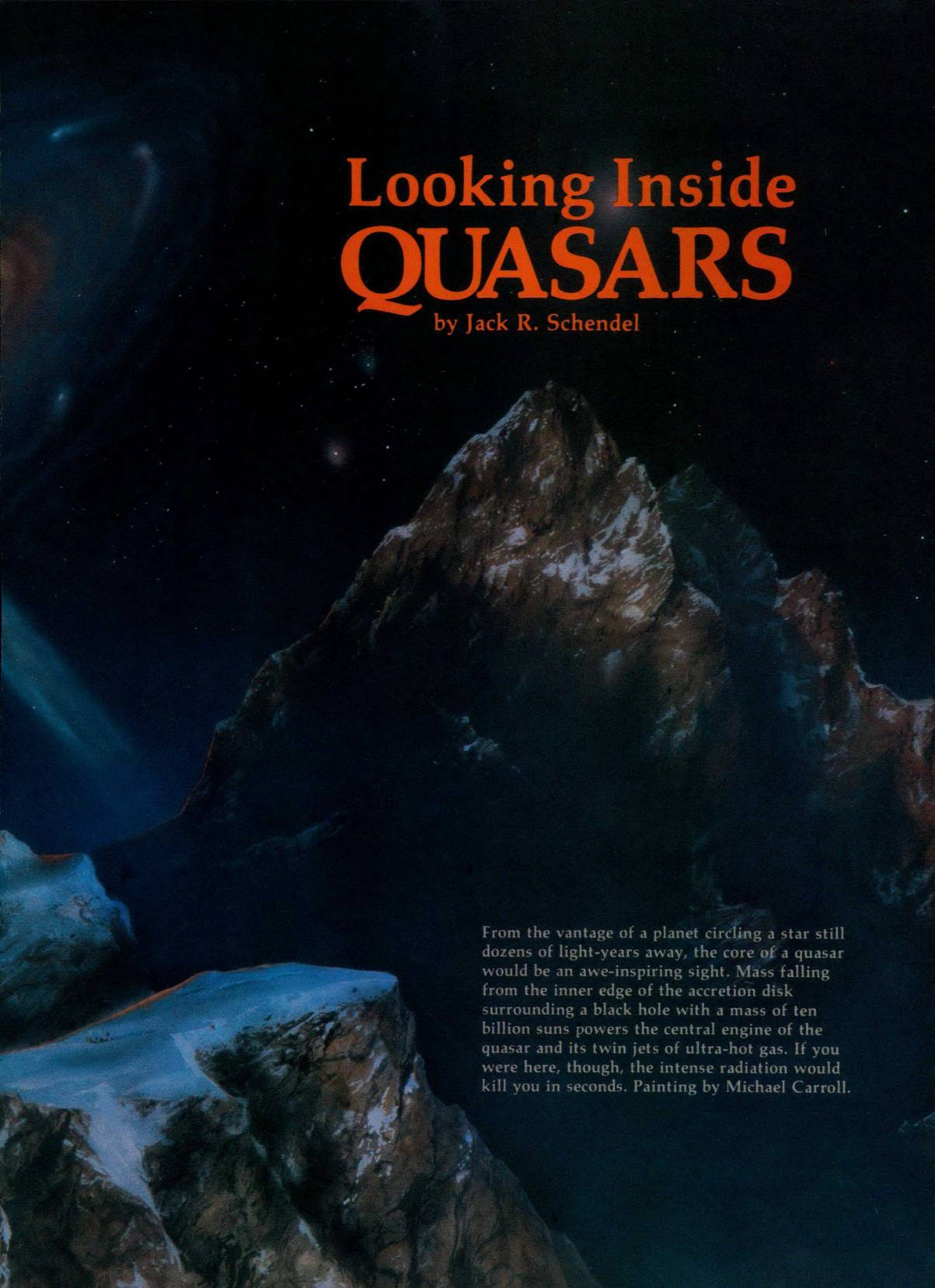
Film Production
Driscoll:Graphics Co.
Printer
W.A. Krueger Co.
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
250 West 55th St.
New York, NY 10019
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
112 Merton St.
Toronto, Ontario M4S 2Z7
World Newsstand Distribution
Boarts International, Inc.
1633 Broadway
New York, NY 10019

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202. Copyright © 1982 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: **(414) 276-8547** weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $18.00. All foreign: add $5.00 per year; please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. AstroMedia staff: Teresa Banks, Jacquelyn Berger, Merlene Edwards, Wendy Graika, Rosemarie Kearns, Clarita Manto, Maggie Martinez, Rosemarie McVeigh, Sherrie Miller, Bruce Precourt, Susan Robinson, Deborah Weinstein. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.

©M.Carroll

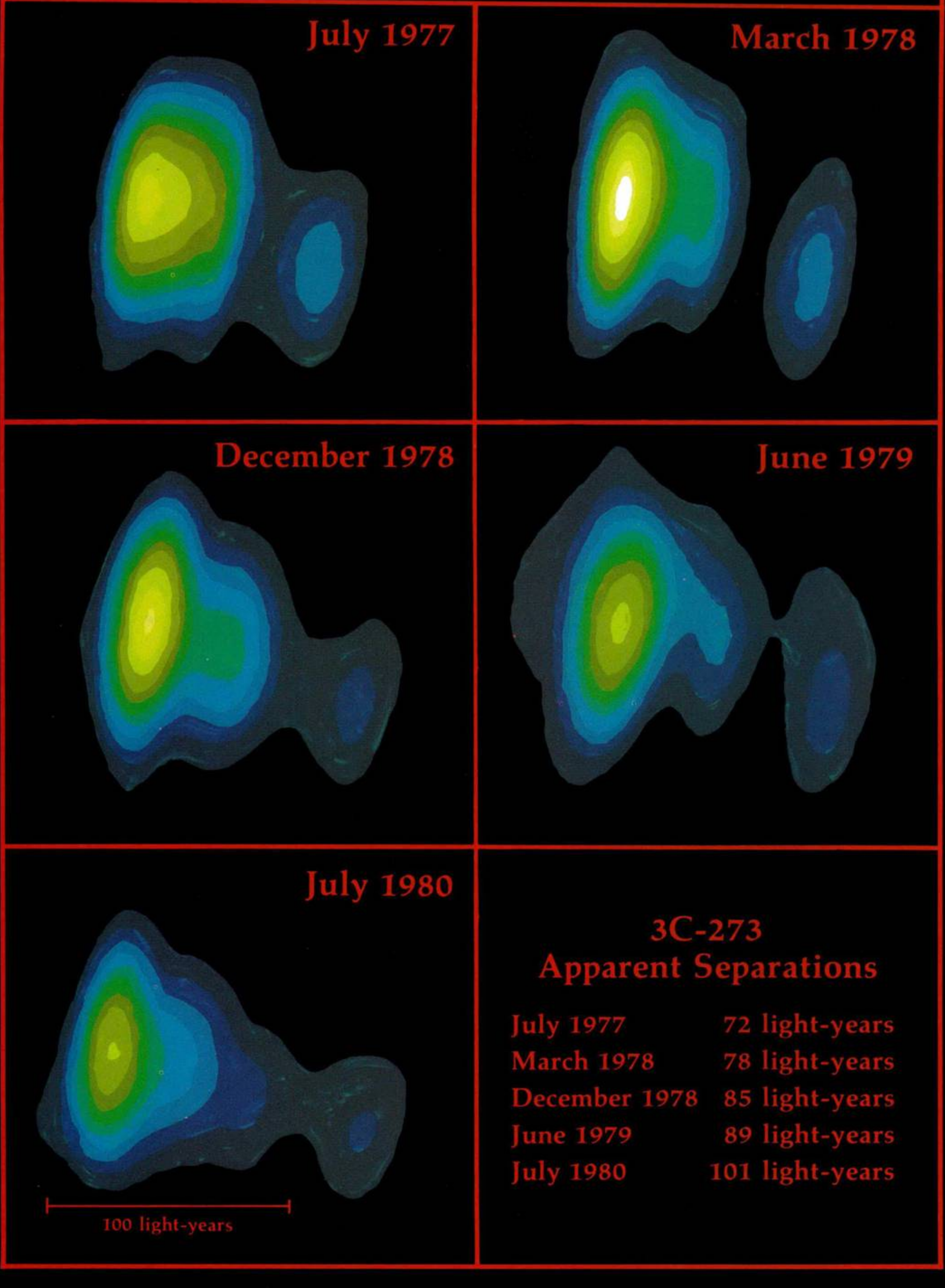
Looking Inside QUASARS

by Jack R. Schendel



From the vantage of a planet circling a star still dozens of light-years away, the core of a quasar would be an awe-inspiring sight. Mass falling from the inner edge of the accretion disk surrounding a black hole with a mass of ten billion suns powers the central engine of the quasar and its twin jets of ultra-hot gas. If you were here, though, the intense radiation would kill you in seconds. Painting by Michael Carroll.

3C-273: Faster Than Light?



3C-273
Apparent Separations

July 1977	72 light-years
March 1978	78 light-years
December 1978	85 light-years
June 1979	89 light-years
July 1980	101 light-years

Relativity theory forbids motion greater than the speed of light, but it does not forbid the appearance of superluminal velocities.

Quasars have been known to astronomers for about twenty years. Yet it is only now, two decades after the shock of their discovery, that astronomers have begun to feel confident we know what they are. Quasars are still mysterious; their source of energy, their relationship to galaxies and the formation of the universe are by no means clear, but their basic nature is now at least partly understood.

The story of quasars really began in the 1950s, as radio astronomers mapped the sky and compiled lists of cosmic radio sources. But radio telescopes then lacked resolution — from the data, an astronomer could not tell precisely where his radio source was located in the sky. Obvious sources were no trouble at all — a big gaseous nebula or a bright galaxy near a radio position was presumptive evidence of a hit, an identification of the radio source.

But many radio sources showed no obvious optical counterpart. A good photograph with a large telescope usually showed thousands of faint stars within the position error of the radio catalog. Finding optical counterparts was almost a game, but an important game because astronomers slowly began to suspect that something very important was hiding — perhaps even radio-emitting stars! The third Cambridge catalog of radio sources, called the "3C," was a particularly good hunting ground.

How did astronomers hunt? Sometimes they used a larger radio telescope to narrow the error box, hoping to isolate the optical counterpart. The first quasar to be identified, in 1960, was found this way. Alan Sandage of Hale Observatories announced that a faint bluish star in the constellation Triangulum, a star with unusual spectral lines, corresponded to the 48th source in the 3C list, or 3C-48.

In 1962 Cyril Hazard, using the new 210-foot radio dish in Parkes, Australia, exploited another method — he measured the precise time when the Moon occulted, or blocked, a radio source. In 1963 Hazard announced the precise location of the source 3C-273, and the discovery that it was actually two radio sources on either side of a readily identified 12th magnitude blue star-like object. At first it seemed as if radio stars had finally been discovered.

Maarten Schmidt, a colleague of Hazard's, photographed the new "star" with the 200-inch Mount Palomar telescope. It looked star-like enough, but a thin "jet" stuck out on one side. Schmidt's spectra were also extraordinary. The characteristic spectral lines of known elements were absent, and an entirely different set of lines appeared.

Schmidt pondered the strange spectrum of 3C-273 for about six weeks. Then in a flash of insight, he realized that the spectrum was actually a normal spectrum of hydrogen that had been redshifted by an enormous amount — about 16% — that corresponded to a recessional velocity of 45,000 kilometers per second, or 15% of the speed of light.

The implications were enormous. According to the Hubble Law, 3C-273 must be very far away, among the most distant objects then observed by humans. Looked at from this perspective, the strange spectrum of 3C-48 also suddenly made sense to astronomers — as the spectrum of a source redshifted by 37%, nearly one-third the speed of light. Overnight, quasi-stellar radio sources, QSRS, or the more pronounceable

Quasar 3C-48

Quasar 3C-48 shows a tiny image indistinguishable from an ordinary star even when photographed with the 200-inch Mount Palomar telescope. But its spectrum tells a different story — a portrayal of a distant, violent object shining with the brilliance of a hundred Milky Way Galaxies. Hale Observatories photo.

"quasars," became the hottest thing in astronomy.

Quasar hunting soon became a frantic race to find more and more distant quasars having greater and greater redshifts. Within a few years, two quasars with redshifts greater than 80% had been found. A decade later, several had redshifts exceeding 300%, or about 90% of the speed of light.

After indentifying known objects in radio source catalogs as blue "stars," or "quasi-stellar objects," astronomers began to simply search for extremely blue "stars" — and found that they, too, had high redshifts. These were called blue stellar objects, or "BSOs," at first. Since BSOs turned out to be identical to quasars in every way except that they do *not* emit detectable radio signals, today we include them with quasars. Well over 1000 confirmed and verified quasars are known at present, but millions more, superficially looking like ordinary stars, are just waiting to be discovered.

It didn't take astronomers long to realize that quasars were something very, very different. Because they are so distant, quasars must shine brilliantly. The amount of energy was staggering — a thousand times the total energy output of a normal galaxy. What powers them? Unlike supernovae, for example, which can outshine a galaxy for a few weeks or months, quasars have been shining for decades. Photographic records of 3C-273, for example, go back to the 1880s. But more compelling, the sheer numbers of quasars show they must have long lifetimes — perhaps measured in the millions of years.

Furthermore, the quasar energy source must be extremely small. Not only do observations with high-resolution radio interferometers indicate that the mysterious mechanism in the core of the quasar is less than a few light-years across, but the flickering of quasars themselves often places upper limits on their size of a few light-days' diameter. How could so much energy be produced in such a small space?

Astrophysicists went nuts looking for answers. The energy output of a typical quasar required converting several tens of solar masses each year into raw energy with 100% efficiency. Nuclear processes such as those which power our Sun and other stars are, at best, only about 1% efficient. Even if a theoretical "superstar" with a million solar masses could form, it couldn't put out the amount of energy a quasar does for the length of time we know that quasars have existed.

Perhaps, they argued, quasars are chains of supernovae exploding deep in the hearts of distant galaxies. Suppose in a dense cluster of stars one supernova were to set off others? Or maybe it's a cluster of "superstars" or pulsar-like objects spinning and collapsing? Or anti-matter meeting matter — with total annihilation? Or "white holes," places where energy might gush into our universe from somewhere else?

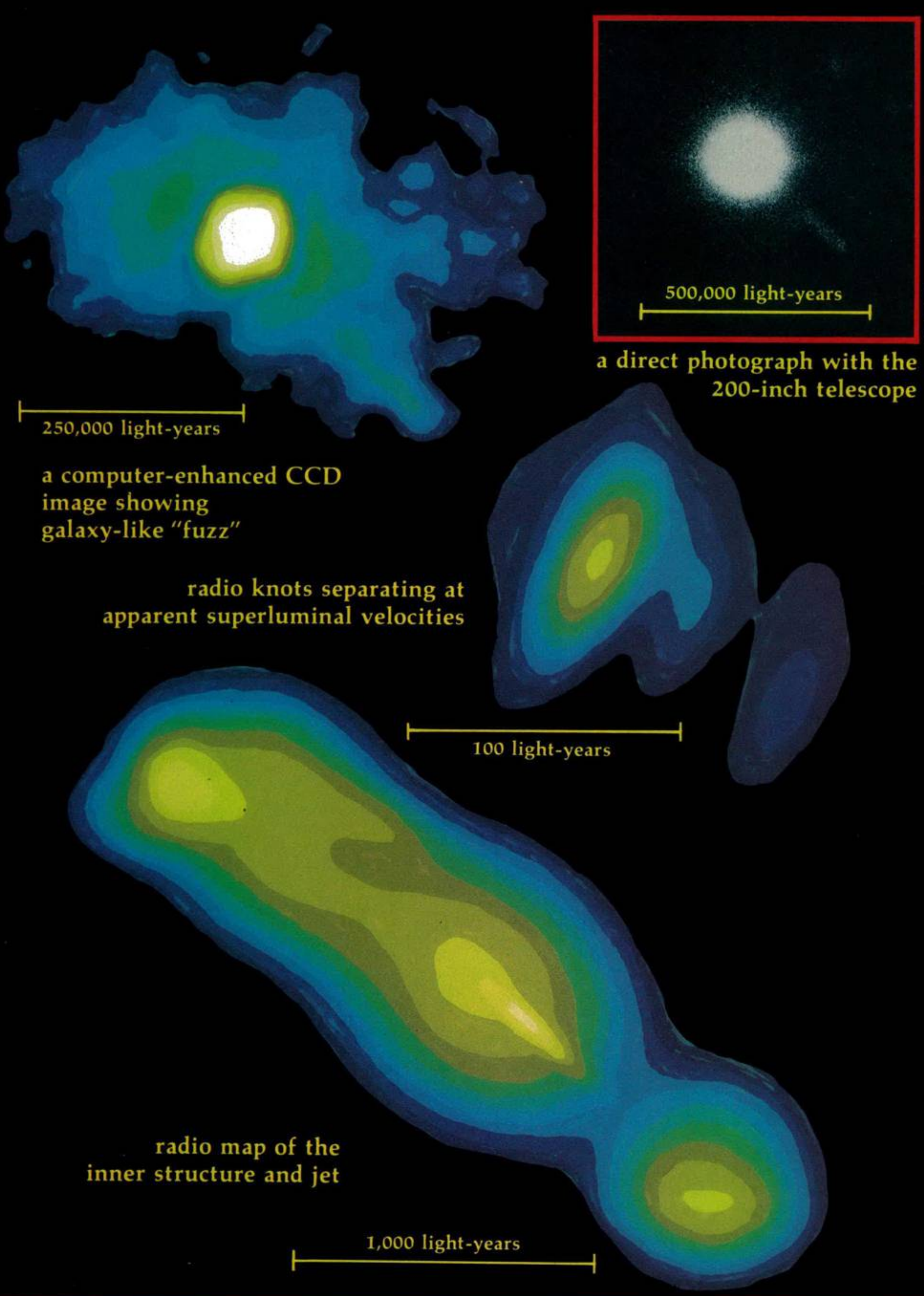
Of all the possibilities, the "central black hole" hypothesis has slowly become most accepted. Quasars, astronomers suspect, are relatively ordinary galaxies with a massive black hole at the center. Infalling gas ejected from the stars in the galaxy in their normal course of evolution powers it. The gas accumulates in a ring of gas — an accretion disk — that circles closer to the black hole, while getting hotter and hotter from tidal squeezing and emitting powerful blasts of X-rays, ultraviolet light, and radio waves. Meanwhile, strong magnetic and electrical forces squirt twin jets of electrons from the poles at nearly the speed of light.

In the end, it's gravity that drives a quasar — by the gravitational energy liberated as matter falls into the supermassive black hole's bottomless

Blazar BL Lac

Blazars seem to be a cross between quasars and ordinary galaxies. The bright core emits radio and infrared light like a quasar — but surrounding it is a "fuzz" of starlight and images of other faint galaxies. Blazars provide compelling evidence that quasars, too, are very distant, powerful objects. Kitt Peak photo.

Profile of Quasar 3C-273


250,000 light-years
500,000 light-years
100 light-years
1,000 light-years

Hale Observatories photo

a direct photograph with the 200-inch telescope

a computer-enhanced CCD image showing galaxy-like "fuzz"

radio knots separating at apparent superluminal velocities

radio map of the inner structure and jet

The Central Engine

What kind of "machine" pours out the energy of a thousand galaxies from a volume smaller than that of our solar system? The answer is: whatever lies at the heart of a quasar.

How can we ever find out anything about an object so remote, so small, so beyond anything we know? That answer lies in observation, the exercise of logic, and calculation. We must investigate what such an object does, imagine what it could be, and test our ideas rigorously.

We know the source is small because we see it vary in brightness by fairly large amounts — tens of percent — in only a few days. Since the source cannot be much smaller than the time it takes light to cross it, we know it's less than a light-day, or several tens of billions of kilometers across.

We know the energy output, no matter how unbelievable it seems, is prodigious because we have now observed a reasonable sample of quasars and quasar-like objects embedded in or surrounded by distant galaxies. We cannot hope quasars are close by and therefore "tame." We are forced to consider violent processes that release lots of energy in small regions of space.

We must account for their longevity — the central engine of a quasar runs for millions of years. We see evidence for this in those vast twinned gas clouds millions of light-years across that poured from the quasar jets. And we can't explain them away as big explosions: there are simply too many quasars out there if they are not long-lived.

But we have a further clue: the jets have maintained their orientations for millions of years. Whatever powers quasars is also something that maintains its orientation in space — like a gyroscope. The quasar engine, it seems, is something that spins.

Twenty years ago when quasars had just been discovered, they seemed inexplicable because astronomers knew of fewer ways to generate energy — and the ways they knew of were far less efficient. Nuclear reactions, at best, return a fraction of a percent of the energy content of matter, and the energy pouring out of quasars required far too much matter to fit in the volume that they knew quasars occupied.

In the two decades since, observations of novae, supernovae, pulsars, and neutron stars have shown beyond any reasonable doubt that immense amounts of energy are released when mass falls into strong gravity fields.

But more exotic objects exist in astronomers' imaginations — objects so compact that light cannot escape them. Black holes, as we call them, though not directly observed, probably exist in reality, too.

The quasar engine, then, is likely to be a massive spinning black hole surrounded by a huge, hot whirlpool of inwardly spiraling gases. How massive? The range runs in the billions of solar masses — enormous by stellar standards, but only a few percent of the mass of a typical galaxy. How big? A billion-solar-mass black hole would be about the diameter of the solar system. That's the right size! What about the supply of matter? In a normal galaxy, old stars throw off enough gas to supply these gravitational whirlpools — called accretion disks by astronomers — for the millions of years required.

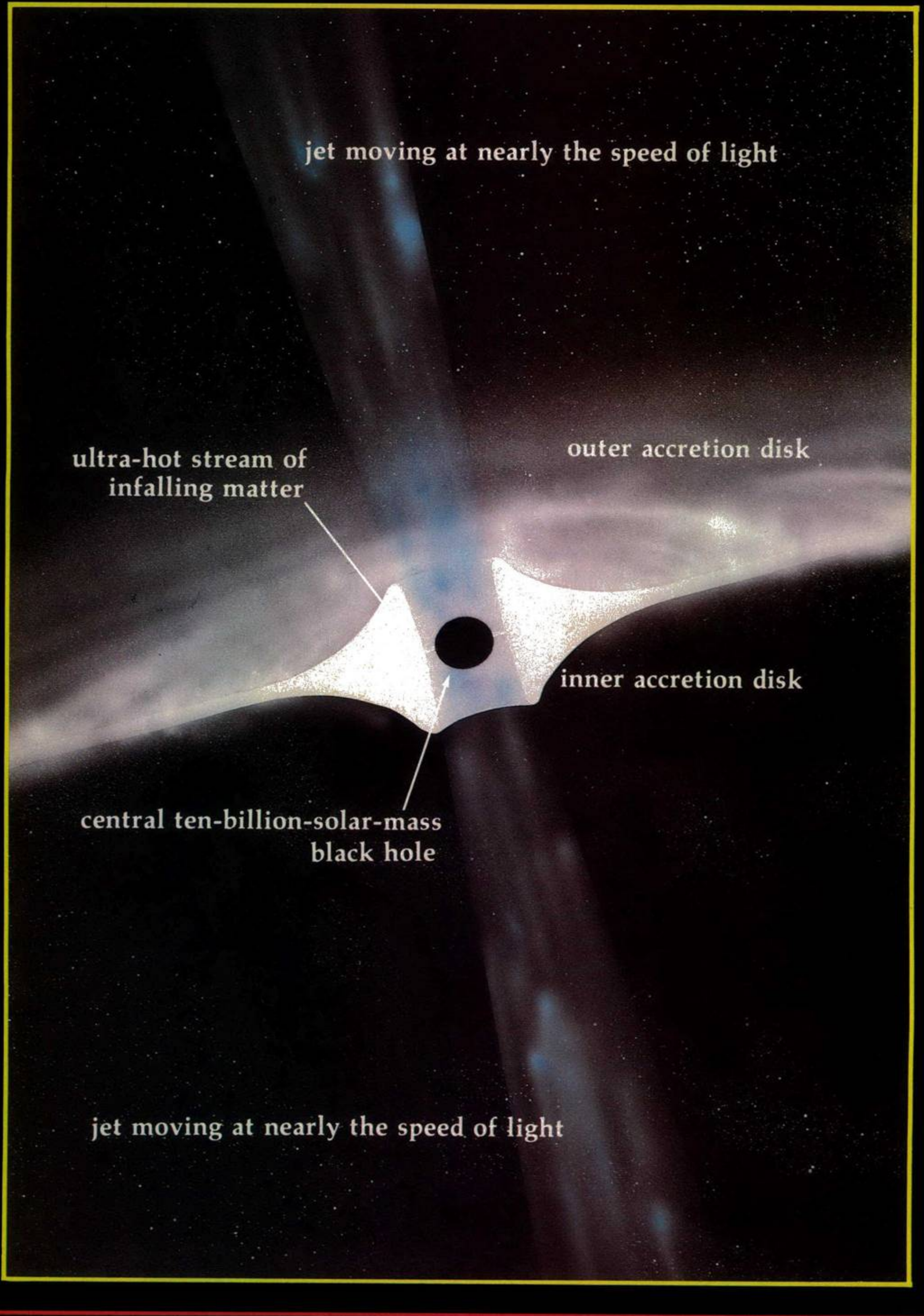
As it circles the black hole, gravity compresses the gas; magnetic fields embedded in it get dragged along and compressed also. The gas heats up, circling the black hole, and radiates energy at all wavelengths. It spirals inward until, at the inner edge of the whirlpool, it whips around at thousands of kilometers per second.

In this super-hot stream of magnetized gas, some particles gain enormous energy and escape in the only directions they can go — straight outward from the accretion disk and at right angles to it. These are the jets, aimed and held steady by the spin of a black hole.

As long as a thin, steady stream of gas dribbles into the black hole — being heated to millions and then billions of degrees, giving off blasts of radiation and hurling particles out along the spin axis of the accretion disk — all is well. But if by some chance a large burst of gas falls in, the resulting blast of high-energy radiation quells the flow temporarily, the quasar flickers, and the jet falters.

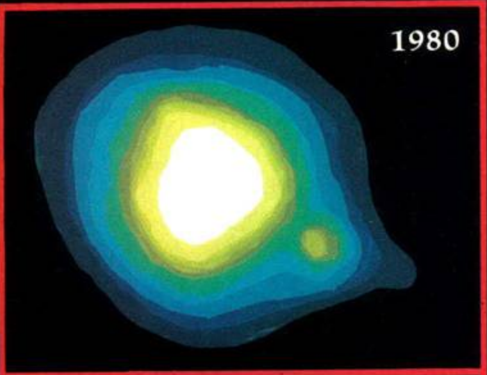
How did the black holes arise in the first place? Astronomers really don't know. Perhaps not long after the formation of the universe, they acted as nuclei around which the galaxies formed. Or perhaps galaxies formed without black holes, which subsequently evolved when the dense stellar cores of some galaxies collapsed catastrophically inward on themselves. Astronomers do think that there are fewer quasars now than there were in the distant past.

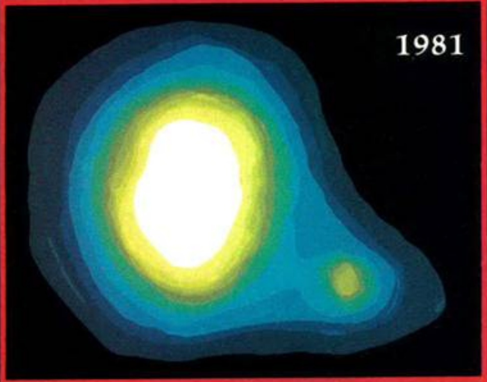
Can we trace their histories? When we look into the depths of space, we're looking into the past. Astronomers want to look farther into space to see if there was once a time before any quasars shone. And today — where are they? Quite possibly the black holes are still there — whirling in the hearts of many galaxies, quiescent now that the energizing flow of gas has slowed or stopped.

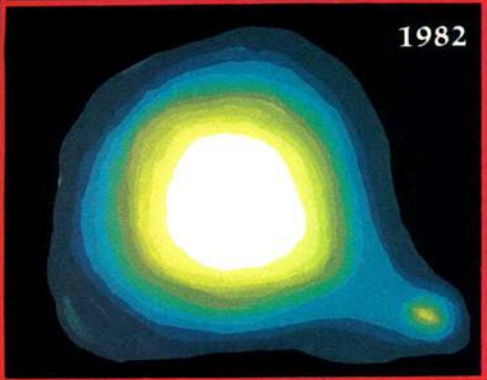

jet moving at nearly the speed of light
ultra-hot stream of infalling matter
outer accretion disk
inner accretion disk
central ten-billion-solar-mass black hole
jet moving at nearly the speed of light

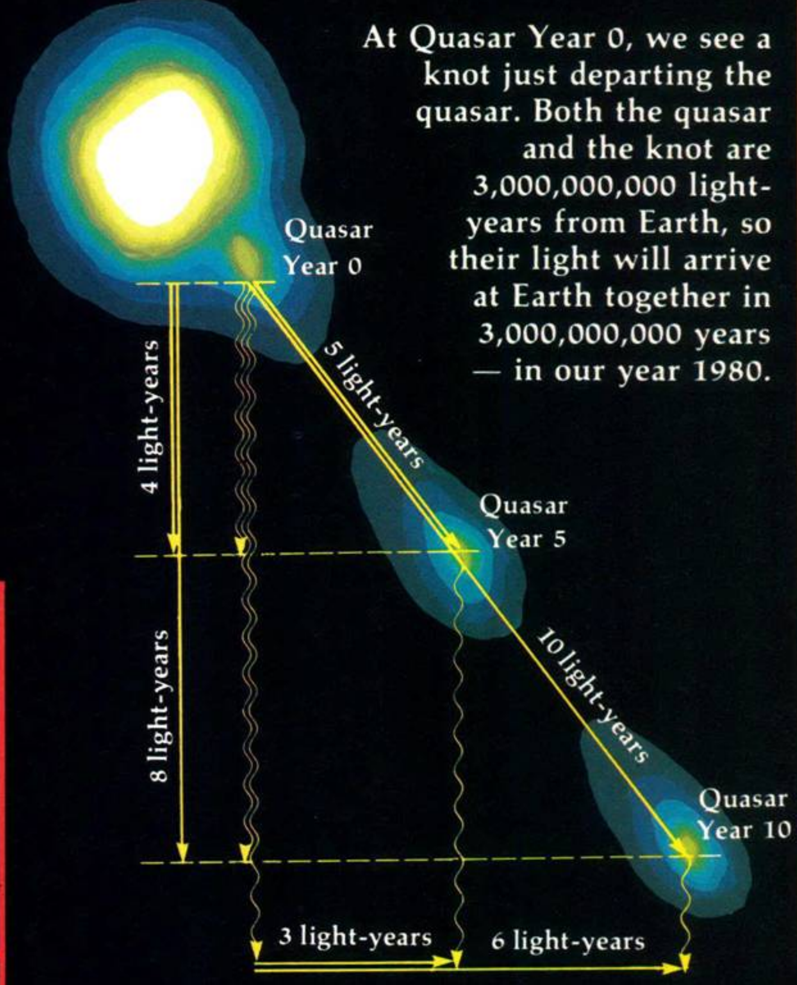
Apparent Superluminality

The Illusion: From Earth, we have seen a bright knot move 6 light-years across our line of sight in the two years between 1980 and 1982. We conclude that it must be moving at 3 times the speed of light.








Quasar
Year 0
5 light-years
4 light-years
Quasar
Year 5
8 light-years
10 light-years
Quasar
Year 10
3 light-years
6 light-years

At Quasar Year 0, we see a knot just departing the quasar. Both the quasar and the knot are 3,000,000,000 light-years from Earth, so their light will arrive at Earth together in 3,000,000,000 years — in our year 1980.

At Quasar Year 5, the knot, moving at almost the speed of light, has traveled 5 light-years. It is now 4 light-years closer to Earth and has moved 3 light-years across our line of sight. Light now leaving the knot will reach Earth in 2,999,999,996 years, in 1981. Quasar light due to reach Earth in 1981 has already been traveling for 5 years.

At Quasar Year 10, the knot is 8 light-years closer to Earth, and has moved 6 light-years across our line of sight. The knot's light will need 2,999,999,992 years to reach Earth, and so will arrive in 1982. Quasar light that will arrive in 1982 has already been traveling for 10 years.

gravitational well.

The idea has appeal because it implies that quasars are not something *totally* different than other objects we know, but simply an extreme form of something astronomers suspect is widespread. Many radio galaxies show the characteristic twin jet structure of quasars. Blazars and Seyfert galaxies, two types of active galaxies, show the same violent motions and hot gases. Quasars seem to be part of a continuous sequence beginning with normal galaxies having dense stellar cores, to normal galaxies harboring smallish black holes (as our own Milky Way Galaxy may), to active galaxies, through blazars, strong radio galaxies, and ending with quasars. Quasars — mysterious, powerful, and exotic as they are — began to seem tractable.

Then in the 1970s more perplexing evidence came to light. New radio observations of the central cores of several quasars showed two or more components separating at speeds greater than the speed of light!

But how could that be? Einstein's theory of relativity expressly rules out the possibility that anything can go faster than light.

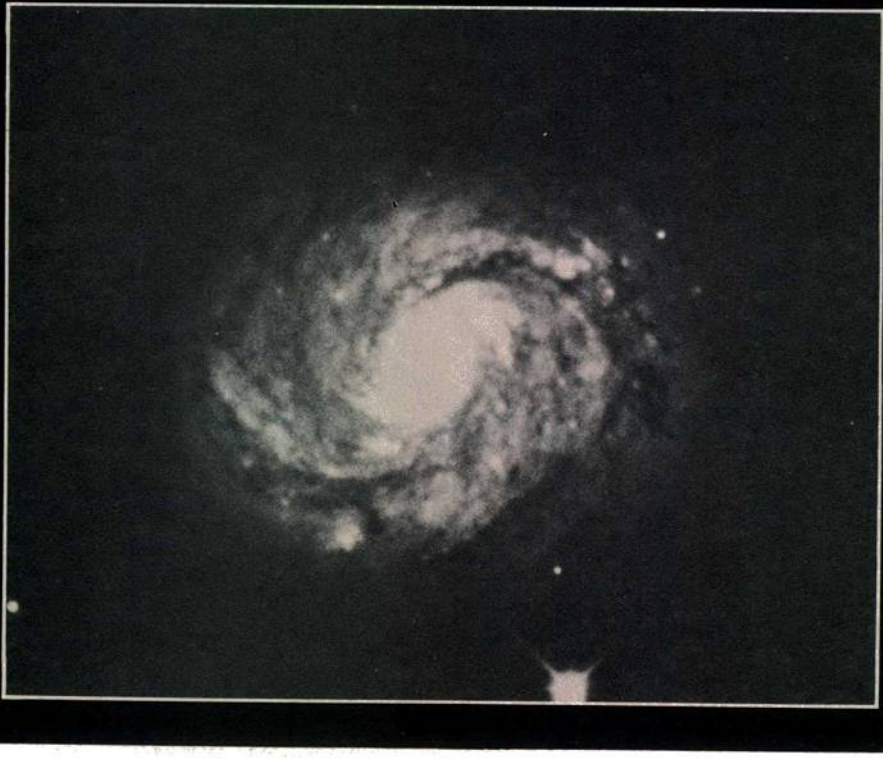
Whether it made sense or not, however, astronomers collected more data. These confirmed that 3C-273 is consistent with a double source separating at four times the speed of light. But ambiguities in that technique allowed the data to be explained equally well as more than two sources which varied in brightness. To understand what was going on in the central cores of quasars, astronomers needed a sharper look.

Radio astronomer A.C.S. Readhead and his collaborators provided a new technique at Caltech's Owens Valley Radio Observatory. In 1978, Readhead and P.N. Wilkenson proposed an improvement to obtain higher resolution. All radio interferometer techniques rely on the fact that the radio waves from a single source such as a quasar arrive at any two radio telescopes on Earth slightly out of phase. This is because the distance between the source and each of the two telescopes is slightly different. When the signals received at the same time by the two telescopes are combined, usually by a computer, the phase differences between the two signals can be used to pinpoint the position of the source almost as accurately as a telescope whose diameter is equal to the distance between the two telescopes. Since the telescopes can be thousands of miles apart, this is clearly a powerful technique.

However, several uncertainties proved difficult to circumvent. The first and most important is timing of the signals. In order to recombine them, the arrival times of the signals must be clocked very accurately. But the timing problem yielded to highly accurate maser clocks.

Another uncertainty lay in the distance between the radio telescopes. So sensitive is the method that even variations of position due to geological processes such as continental drift can affect recombining the signals over a period of time. This problem is much more difficult to overcome than timing since we cannot ask the Earth to stand still. How could this problem be circumvented?

Readhead and Wilkenson borrowed an idea known as the *closure phase*, which had first been proposed by R.C. Jennison in 1958 for portable radio telescopes. It requires at least three telescopes. Phase information from the telescopes, a measure of the time delay between them, must form a closed loop. Astronomers recombine the signals in such a way that the uncertainties in the relative positions of the telescopes cancel out. By relating phase information



Seyfert galaxy M-77

Seyfert galaxies, though not as violent, still display many of the characteristics of quasars. M-77 has a bright, nearly star-like nucleus, powerful infrared emission, and a spectrum suggesting rapid motion in the core. Many Seyfert galaxies could, if they were more distant, be mistaken for quasars! Lick Observatory photo.

of the first telescope to the second, second to third and finally third to first, thus closing the loop, the uncertainties can be nearly eliminated. Readhead and a large list of collaborators began gathering data for a closer look at the quasars.

They used a network of radio telescopes which at times included telescopes at the Max Planck Institute for Radio Astronomy in Effelsberg, Germany; Haystack Observatory in Massachusetts; and the National Radio Astronomy Observatory in West Virginia, among others.

The radio maps they produced showed typical quasars with one very bright component and several dimmer secondary sources. From their maps, it seemed that the bright source was emitting a stream of material in the direction of the dimmer source. The stream of material is the "jet" while the secondary sources are known as "knots."

This type of structure is familiar to astronomers. An optical jet in 3C-273 was discovered shortly after the quasar itself was found. Other, more familiar objects also have jets. The giant elliptical galaxy M-87 at the heart of the Virgo cluster of galaxies has an optical jet with knots emanating from a strong central source, and a much longer radio jet. These jets, however, extend thousands and even millions of light-years.

Readhead's observations, however, produce a far more detailed picture of the central portion of the jets — the innermost few millionths of their total length. The optical jet in 3C-273, for example, is approximately twenty arc-seconds long, corresponding to a length several times the diameter of our Milky Way Galaxy, or 160,000 light-years. The inner jet region mapped by the new technique is two thousand times smaller, only 10 milli-arc-seconds, or about 80 light-years.

The closure phase technique was turned to answering the question: Are the inner components of quasars separating at speeds greater than the speed of light?

Readhead and his collaborators began monitoring 3C-273 in 1977. Over a three-year span, their maps showed a very bright source emitting a jet which contained a knot. The knot appeared, quite clearly, to be moving away from the central source at 9.6 times the speed of light. Since this result was based on the most detailed radio maps ever produced, it was hard to question.

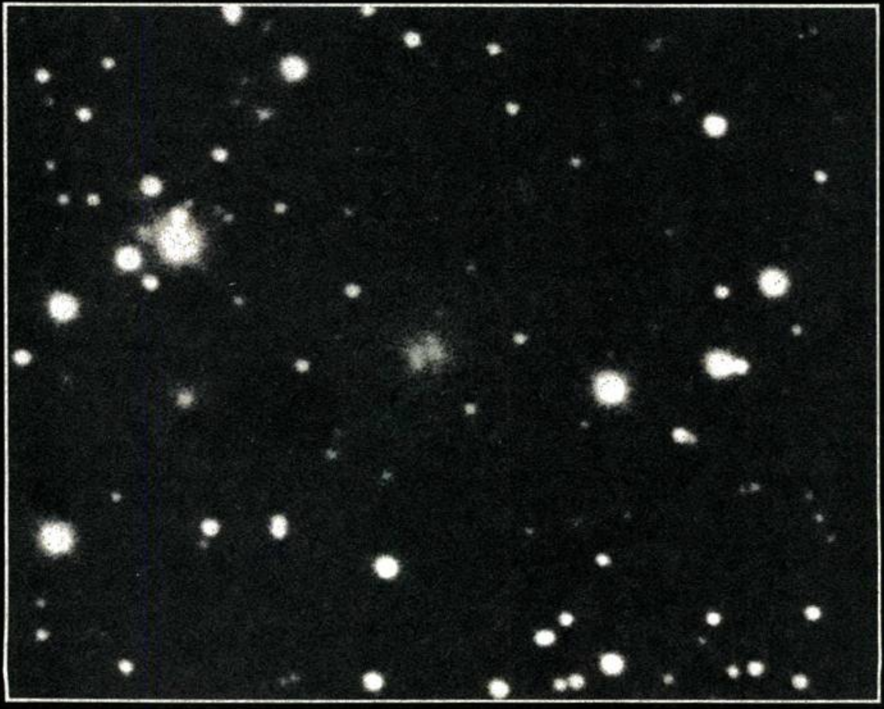
Can it be that the two sources are actually moving away from each other at a speed considerably greater than the speed of light? This is in direct contradiction to Einstein's theory of relativity, which implies that an infinite amount of energy is required for an object to accelerate to the speed of light. To put it bluntly: Was Einstein wrong?

The answer, expressed with classic scientific caution, is: "probably not."

To understand what is happening, we must first examine what we have actually measured. The maps are radio wave intensities plotted against angles on the sky. By comparing radio maps made at two different times, we measure the rate at which the *angle* between the central source and a knot in the jet increases. That rate, known as the angular velocity, is the quantity actually measured.

Spatial velocity can be *inferred* from the angular velocity by combining it with the distance to the quasar. Using the cosmological distance implied by the quasar redshift measurements, the spatial velocity is nearly ten times the speed of light.

However, some astronomers believe that superluminal velocities show that quasars are much closer than the Hubble Law would place them. If



Cygnus A

Radio galaxy Cygnus A was a forerunner of things to come. Identified in 1954, this inconspicuous object emits 10 million times the radio energy of a typical galaxy. Most of the radio signal comes from two lobes on either side of the galaxy itself — vast clouds of electrons shot out from the active galaxy between them. Lick Observatory photo.

quasars were only a tenth of the distance away, then the velocities would be less than the speed of light. Still, most astronomers think that there is overwhelming evidence that quasars really are at the cosmological distances implied by their redshifts. One of the main reasons for this is that blazars, quasar-like objects, certainly lie at the distances implied by their redshifts. Why? We can see light from normal stars in the galaxy that surrounds a blazar, and it, too, is redshifted. Thus even the "heretic" astronomers believe the distances to blazars. And if blazars and quasars are related, there is no reason to think that quasars are nearby while blazars are distant.

Recently, however, two groups of astronomers have detected "fuzz" around 3C-273, suggesting that this most famous of all quasars lies at the center of an elliptical galaxy. Furthermore, clusters of galaxies have now been photographed around other quasars. This has convinced almost all astronomers that quasars are distant.

So it would seem then that most astronomers believe that Einstein was wrong?

Not at all. We must be careful in our interpretation of Readhead's results and what Einstein's theory of relativity really implies. Although relativity theory forbids material objects from traveling at speeds greater than the speed of light, it does not prohibit the *appearance* of superluminal velocities. Einstein's theory predicts that some objects which are moving at *less* than the speed of light will appear to be moving *faster* than the speed of light. These phenomena arise because light or any other electromagnetic signal travels at the finite speed of light.

The explanation for superluminal velocities was proposed by Martin Rees of the Institute of Astronomy at Cambridge, England, and Roger Blandford of Caltech. Imagine a central source, such as a quasar's massive black hole, emitting a jet of subatomic particles nearly along our line of sight. In the jet is a brighter region, or knot, moving away from the central source at nearly the speed of light. (See diagram on page 14.)

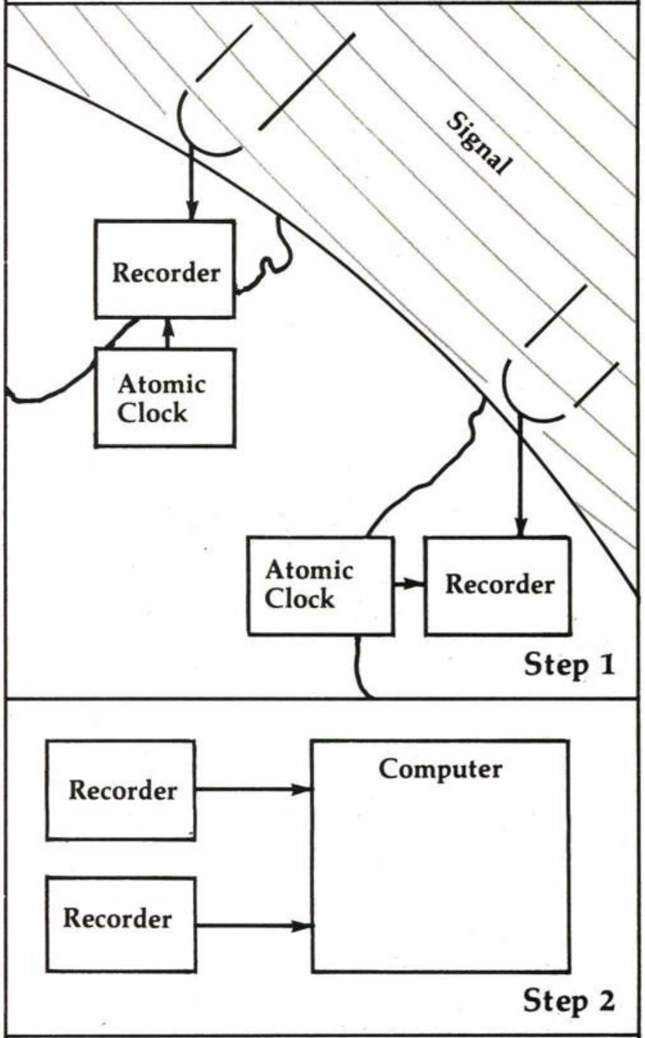
Light and radio waves move at the finite speed of light, so the radio and optical images recorded on Earth left the central source and the knot at different times. Since the knot is closer to Earth because it is moving toward us, radio waves from the central source must leave it earlier and then catch up to the knot.

From that time on, the radio waves from the knot and the radio wave emitted earlier from the central source travel together — eventually arriving at Earth at the same time. There they are recorded.

But during the "catch-up" time, the knot continues to move. In effect, what Readhead and his collaborators measure as a superluminal velocity is an optical illusion, a comparison of the central source at one time with the knot at a later time, after it has moved closer to Earth along the jet.

Thus we see that the *appearance* of superluminal velocities does not require material actually moving at superluminal speeds. Apparent velocities of about 100 times the speed of light could be observed if the speed of the knot were nearly the speed of light and the angle between the line of sight to the quasar and the jet were very small.

VLBI: Key to Resolving the Quasars



A Very Long Baseline Interferometer (VLBI) uses two or more dishes separated by hundreds or thousands of miles, and records the signals on tapes. By knowing exactly how the dishes were originally spaced, radio astronomers can play back the tapes into a detector with exactly equal time delays — just as if the signals came from a single giant dish or interferometer. VLBI gives astronomers great ability to separate close radio sources such as quasars.

Although phase effects can reconcile superluminal velocities of the knots, there are still problems. For example, what *are* these knots we see in the jets? Any real answers must await more observations — but already there are several theories.

Two highly plausible models have been proposed, one by Roger Blandford and Arieh Konigl of Caltech and another by Alan Marscher of the University of California at La Jolla.

Both models assume a jet composed of hot ionized gas, or plasma, traveling outward from the quasar at nearly the speed of light. Embedded in the jet is a magnetic field. Electrons in the plasma spiral along the magnetic field lines producing synchrotron radiation — the radio emission we measure with our radio telescopes. The brightness of the jet, that is, the amount of synchrotron radiation it gives off, depends on two crucial factors: the internal energy of the electrons and the magnetic field strength. If either or both of these increases, the amount of synchrotron radiation also increases.

Alan Marscher's model relies on a principle known as "conservation of magnetic flux." Magnetic flux is a measure of the number of magnetic field lines passing through an area. A weak magnetic field spread over a large area can have the same magnetic flux as a strong magnetic field squeezed over a small area. The conservation of magnetic flux simply means that a magnetic flux in a highly conductive plasma (such as the gas of electrons in a jet) always remains the same.

Suppose that the plasma flowing out the jet is perturbed, perhaps by a small variation in the flow, so that the magnetic field in a region increases. The increase in the magnetic field causes an increase in the synchrotron radiation, which means that the electrons radiate away more energy. The electron gas therefore becomes cooler, and the local pressure drops, causing the region to collapse.

However, the collapse causes the magnetic field to increase again because the magnetic flux must remain constant. This again leads to an increase in the magnetic field and the synchrotron radiation, cooling the electrons more, and causing a further drop in the pressure, causing further collapse — and so on.

The end result is an instability which converts the internal energy of the electrons into synchrotron radiation at an ever-increasing rate.

At first it seems that this model predicts that a knot will collapse in a blinding flash of light and radio waves. However, this is not the case. The magnetic field eventually becomes so strong that it exerts a force acting against further collapse. The knot expands again, but since the forces causing the collapse and expansion do not balance exactly, the knot will bounce, alternately expanding and collapsing. Eventually, expansion dominates and the knot slowly expands until it fades back into the jet and disappears.

If the magnetic model is correct, we should observe knots which move down the jet at a constant velocity. Their luminosity should rise at an increasing rate for a while, then oscillate in brightness while fading away.

Blandford and Konigl's shock-wave model relies on the formation and dissipation of a shock wave in the jet. Suppose that an obstacle, perhaps a supernova remnant or a cloud of interstellar gas, wanders into the path of the jet. This will create a dense region in front of the obstacle where material simply cannot get out of the way fast enough — in much the same manner as a supersonic airplane creates a sonic boom.

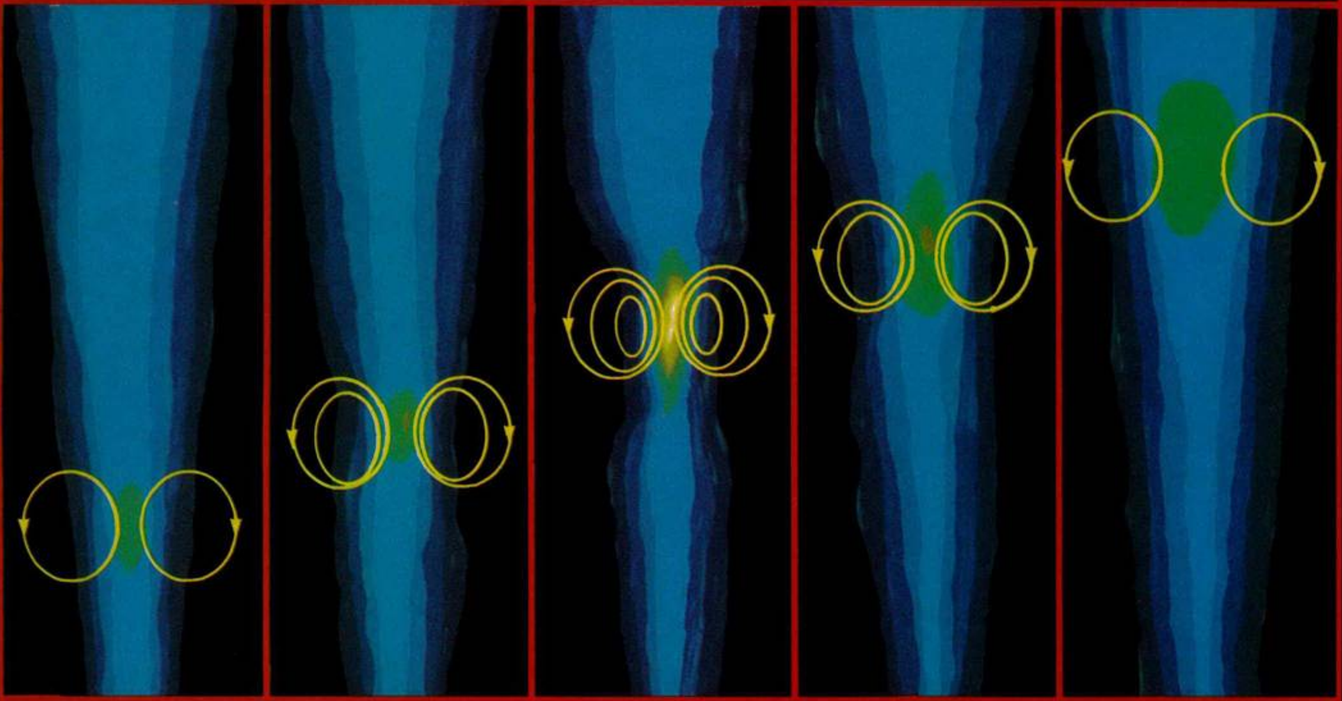
Two phenomena then take place. First, the pressure around the obstacle becomes unbalanced, exerting a force on the obstacle to push it along the jet. Secondly, the electrons in the plasma ahead of the obstacle gain energy, or become hot. The increased electron energy causes extra synchrotron radiation and we see a bright knot.

Meanwhile, the obstacle picks up speed until it is moving at the same velocity as the rest of the jet. This

Centaurus A

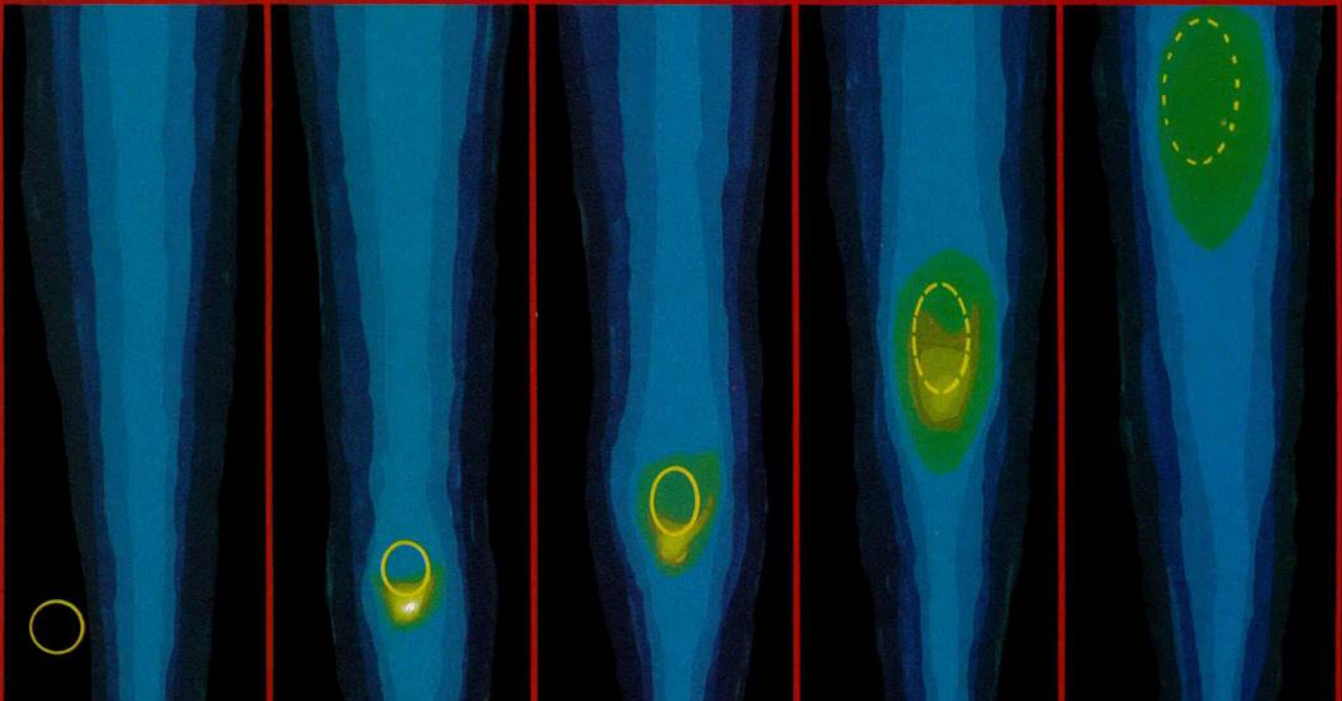
"Mini-quasar" NGC-5128 shows that not all quasars are distant! In looking at radio source Centaurus A, we may be looking at the remnant of a quasar — a galaxy with a worn-out, run-down supermassive black hole now done with all that jetting and emitting, a quasar that has become a mini-quasar on the way to becoming a normal galaxy. Jet-like extensions in this very "deep" exposure are still aligned with the radio lobes emitted millions of years ago. Anglo-Australian Observatory photo.

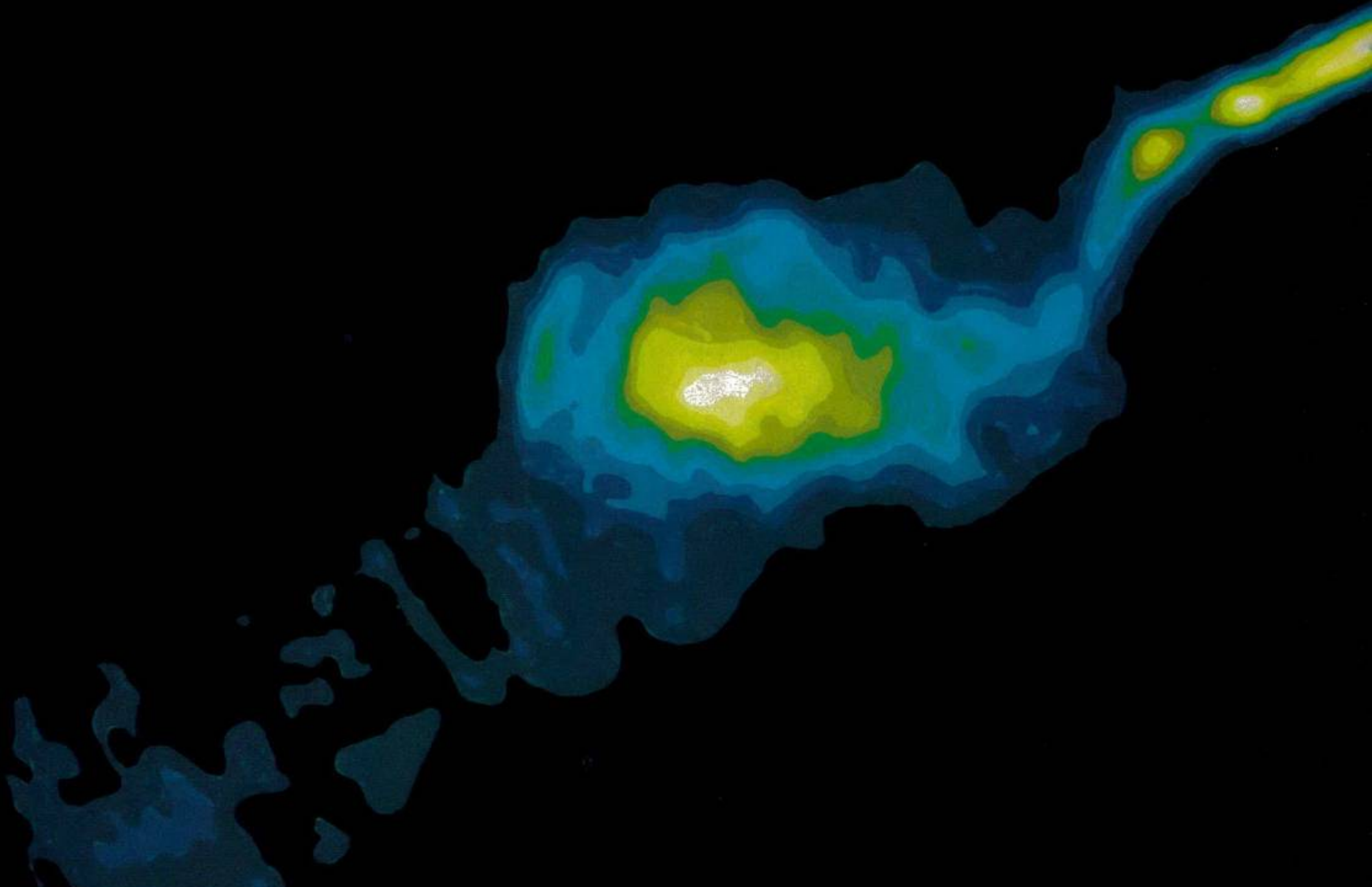
Knot Theories

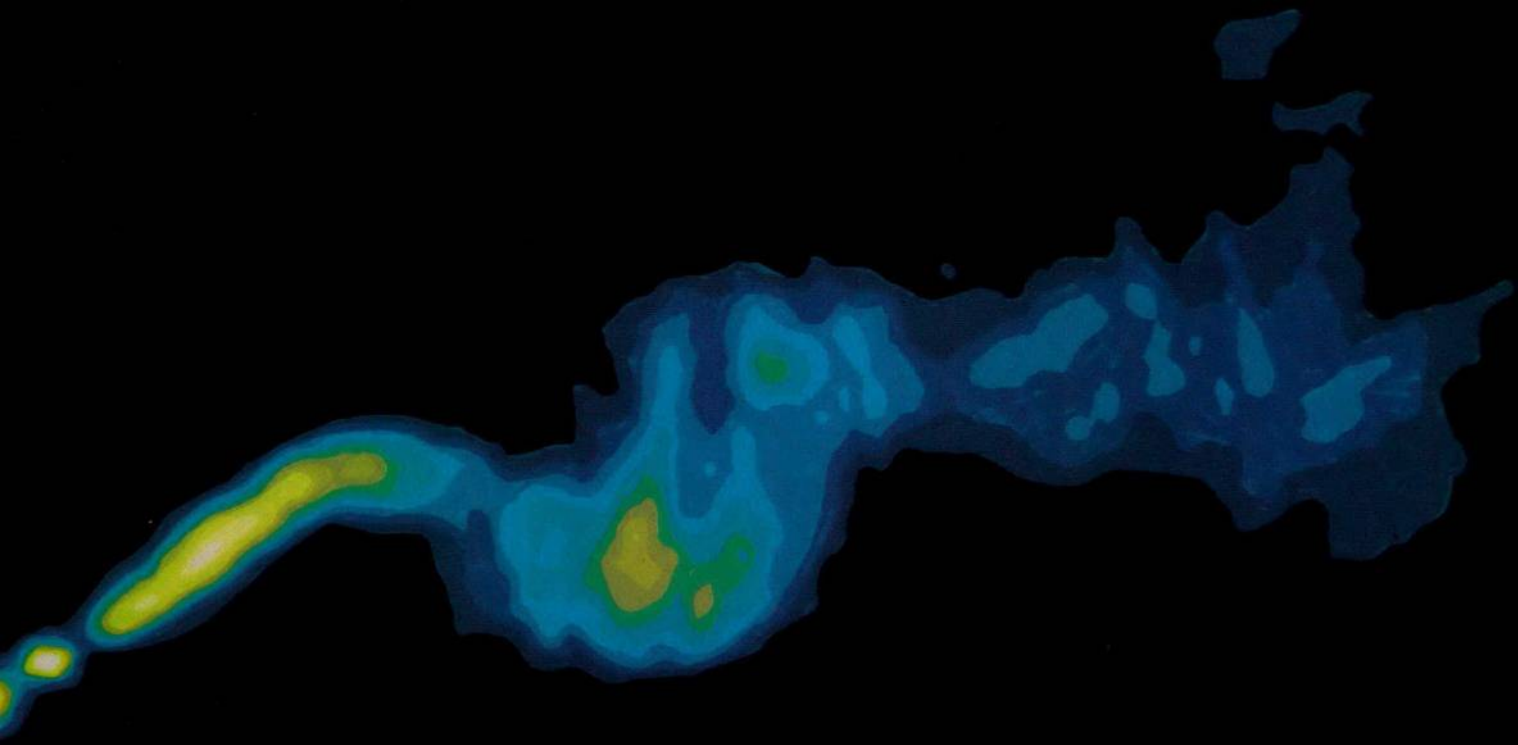


A knot begins when a small perturbation makes a bit of the jet denser than normal. Its magnetic field strengthens; it gets brighter, collapses, then rebounds, disperses, and becomes dimmer.

A knot results from an obstacle getting trapped in the jet. The jet is heated and glows much brighter. The obstruction is accelerated down the jet and heated until the shock disappears and the knot disperses.







The Fate of a Jet

Decaying jets from radio galaxy 3C-449 spread across a million light-years, showing that whatever powers them has been running for a very long time. As the electrons cool and the magnetic fields lose energy, the jets dim, broaden, and slow down. Why are the jets crooked? It may be that the central source slowly precesses on its axis, spraying the jet across a broad cone and leaving its history traced on the sky.

250,000 light-years

reduces the pressure in the shock, so the synchrotron radiation decreases and the knot fades away.

Observationally, we would see a knot begin as a rapid rise in the luminosity of part of the jet during formation of a shock, followed by a drop in luminosity during acceleration of the obstacle, and ending with the luminosity of the knot equal to that of the jet when the shock dissipates.

This shock-wave model also predicts that the luminosity of the knots should be asymmetric — they will be brightest at the tip of the shock. It also predicts the possibility that a single obstacle will experience forces tending to break it into fragments. Blandford and Konigl suspect that this phenomenon explains the behavior of the five outermost knots observed in the jet of M-87 — which seem to have originated from the fragmentation of one obstacle.

So — what causes knots? At this point it is too early to tell. Both models have had some success. The magnetic model, with its prediction of "bounces" in the luminosity of the knots, matches the phase closure observations of the knot in 3C-273. On the other hand, the shock-wave model explains the multiple knots observed in M-87's jet.

Could it be that both are correct? Magnetic effects may dominate close to the source of the jet while shock effects dominate far downstream in the jet. It is certainly difficult to estimate the likelihood of an obstacle wandering into the jet, but even more difficult, if not impossible, to estimate the likelihood of the onset of enough turbulence needed to start a magnetic collapse.

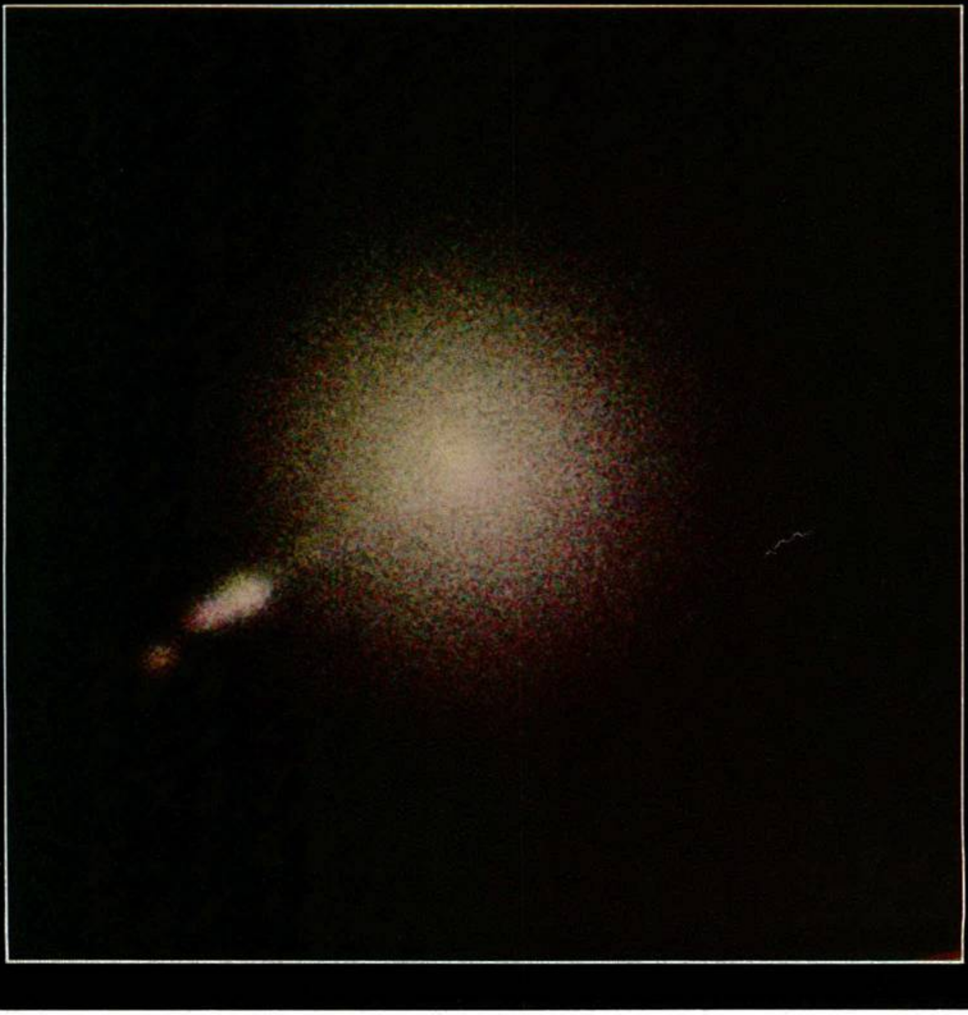
Thus another part of the quasar mystery seems to drop into place. While astronomers don't have a definitive answer, they do have some effective working models.

Yet other questions keep nagging. How did quasars form? When did they form — before or after the galaxies? Are their cores really gigantic black holes?

Ultimately, the answers to these questions will probably rely on some clever astronomer who will provide an even closer look inside quasars.

Image data credits. Cover: computer generated image after Pearson *et al.*, *Nature* 290:365; page 4: Owen *et al.*, *Ap.J.* 239:L11; page 8: Pearson *et al.*, *op. cit.*; page 11: Tyson *et al.*, *Ap.J.* 257:L1; Pearson *et al.*, *op. cit.*; Rees and Simon, *Ap.J.* 152:L145; page 20-21: Perley *et al.*, *Nature* 281:437.

Jack R. Schendel is a staff physicist with the Theoretical Applications Division at Los Alamos National Laboratory. He obtained his Ph.D. from the University of Pittsburgh and has recently been engaged in writing about quasars, blazars, and other cosmic oddities.



M-87

M-87 is not an ordinary galaxy. It is a powerful radio source with a bright, almost star-like nucleus and a jet of hot gases that looks suspiciously like the jet of 3C-273. In this extreme close-up of M-87, made with the 200-inch Mount Palomar telescope, five or six small knots in the jet stand out clearly. Compare this photo with the radio map of M-87 on page 4. Studies of the motions of stars in M-87 suggest that there may be an object with billions of solar masses at its core. Hale Observatories photo.

ODYSSEY

Reach Into The Depths Of The Universe

and save hundreds of dollars with your choice of a powerful Odyssey Telescope

Enjoy the proven performance of these precision telescopes with the breathtaking ability to reveal the universe. Lower priced than many telescopes having only a fraction of their capability, the Odyssey series brings you the universe like no other.

See the colors of the Orion Nebula, the dust lanes in the Andromeda Galaxy, the elusive Veil Nebula, thousands of NGC objects and intricate lunar and planetary detail.

WE IMPROVED THE WAY YOU SEE THE UNIVERSE

The sturdy, stable Odyssey series is still unbeatable for aperture size, price and optical quality. And we still lead the way with dramatic new concepts which have revolutionized amateur observer telescopes.

SIZE. Odyssey telescopes offer you mirror diameters which let you get serious about exploring distant galaxies. You can now see the universe up-close as it really is.

PRICE. We offer low-priced telescopes of remarkable quality, and we sell the precision optics which go into them to observers who build their own instruments.

PRECISION OPTICS. Every Odyssey mirror optic is tested to beat anything in the field for brilliant, quality imagery.

EXPERIENCE THE UNIVERSE IN VISUAL HIGH-FIDELITY

Don't settle for less. Odyssey shows you a visually equalized universe-the correct size-to-brightness relationship of all objects viewed through a telescope.

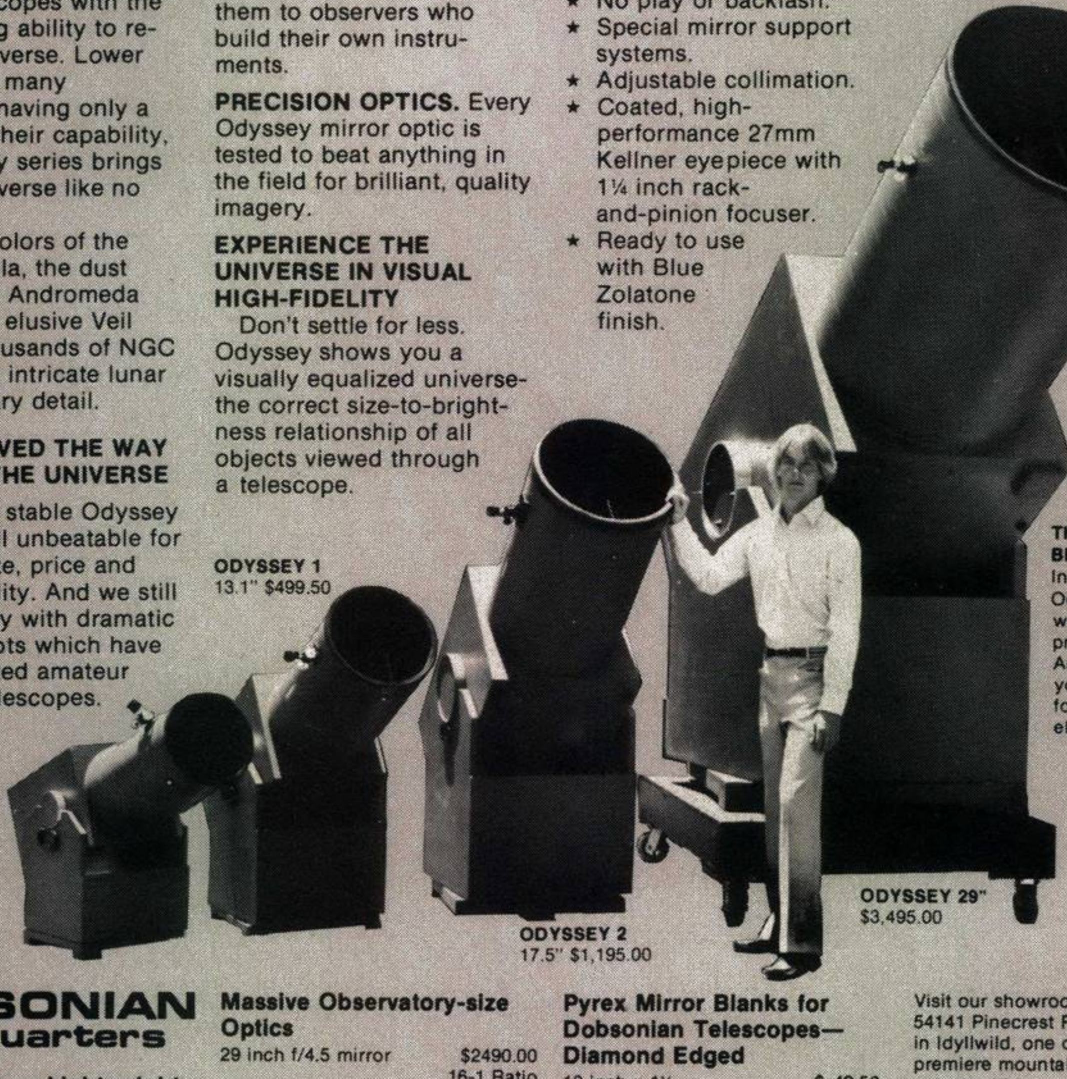
SPECIFICATIONS

All Odyssey telescopes feature:

- ★ Paraboloidal Pyrex mirror, null figured to ⅛th wave, aluminized & overcoated.
- ★ Super smooth and stable Dobsonian alt-azimuth mount with Teflon bearings throughout.
- ★ No play or backlash.
- ★ Special mirror support systems.
- ★ Adjustable collimation.
- ★ Coated, high-performance 27mm Kellner eyepiece with 1¼ inch rack-and-pinion focuser.
- ★ Ready to use with Blue Zolatone finish.

(Shipping charge payable upon delivery, F.O.B. Idyllwild, CA. Prices include crating. California residents — please add 6% sales tax.)

There's lots more available - for free literature on Dobsonian telescopes and parts write us immediately.



ODYSSEY COMPACT
10.1" $299.50

ODYSSEY 1
13.1" $499.50

ODYSSEY 2
17.5" $1,195.00

ODYSSEY 29"
$3,495.00

THE WORLD'S BIGGEST.
Introducing the Odyssey 29 —the world's largest production telescope. And sold for less than you'd expect to pay for the optics alone elsewhere: $3,495.

DOBSONIAN Headquarters

Large Aperture Lightweight Mirror Optics

The emphasis is on performance with these truly revolutionary lightweight mirror optics. You now can build the light, compact large aperture telescope you have always wanted.

Mirrors can be mounted as standard, flat-back or on flotation cells. There are complete instructions with these null figured, ⅛ wave paraboloidal Pyrex mirrors. All are aluminized and over-coated, free of astigmatism, with approximately 13 - 1 diameter-to-thickness ratios. Your satisfaction is guaranteed.

Massive Observatory-size Optics

29 inch f/4.5 mirror	$2490.00 16-1 Ratio
17.5 inch f/4.5 mirror	$ 659.50 13-1 Ratio

Now you can see virtually every NGC object. Faint, undefinable shapes appear in startling detail. Includes diagonal.

Lightweight Mirror Optics at Low, Low Prices:

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
12.5 inch f/4.5 mirror	$259.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50

SHIPPING: Optics prices include shipping in the 48 contiguous states. Shipping to other destinations is additional.

Pyrex Mirror Blanks for Dobsonian Telescopes—Diamond Edged

10 inch x 1⅛	$ 49.50
12.5 inch x 1⅛	$ 79.50
13.1 inch x 1⅛	$ 89.50
17.5 inch x 1 5/8	$249.50
20 inch x 1 5/8	$395.00
22 inch x 1 5/8	$495.00
24 inch x 1 5/8	$750.00
29 inch x 1 5/8	$899.00

Elliptical Diagonals

These coated flats are ready to mount and use. This wide selection is low priced. Guaranteed 1/10 wave. Select the minor axis you need:

1.83" — $15.50
2.14" — $18.95
2.60" — $22.50
3.10" — $34.50
4.25" — $69.50
6.25" — $150.00

Visit our showroom at
54141 Pinecrest Road
in Idyllwild, one of California's
premiere mountain resort
communities

Coulter Optical Co.
the ODYSSEY Telescope people
Dept A-1 P.O. Box K
Idyllwild, CA 92349

We welcome your call:
(714) 659-4621

VISA master charge

California residents add 6% sales tax please

ASTRONOMY FORUM

The League Meets in Peoria

The 36th National Convention of the Astronomical League was held in Peoria, Illinois, in late July. It's not a particularly long drive from Milwaukee, so on Wednesday, July 21, I drove south past Chicago and down Interstate 55, passing miles of central Illinois corn and soybeans, then cut over to Peoria on highway 24, an older two-lane concrete road. The day was hot and humid, but beautiful: wild barley gleamed beside the road, and thunderheads rose into the milky blue sky above gently rolling farm country. I passed through small towns shaded by elms, quiet side streets, and empty lots filled with Queen Anne's Lace, and miles of open farm country.

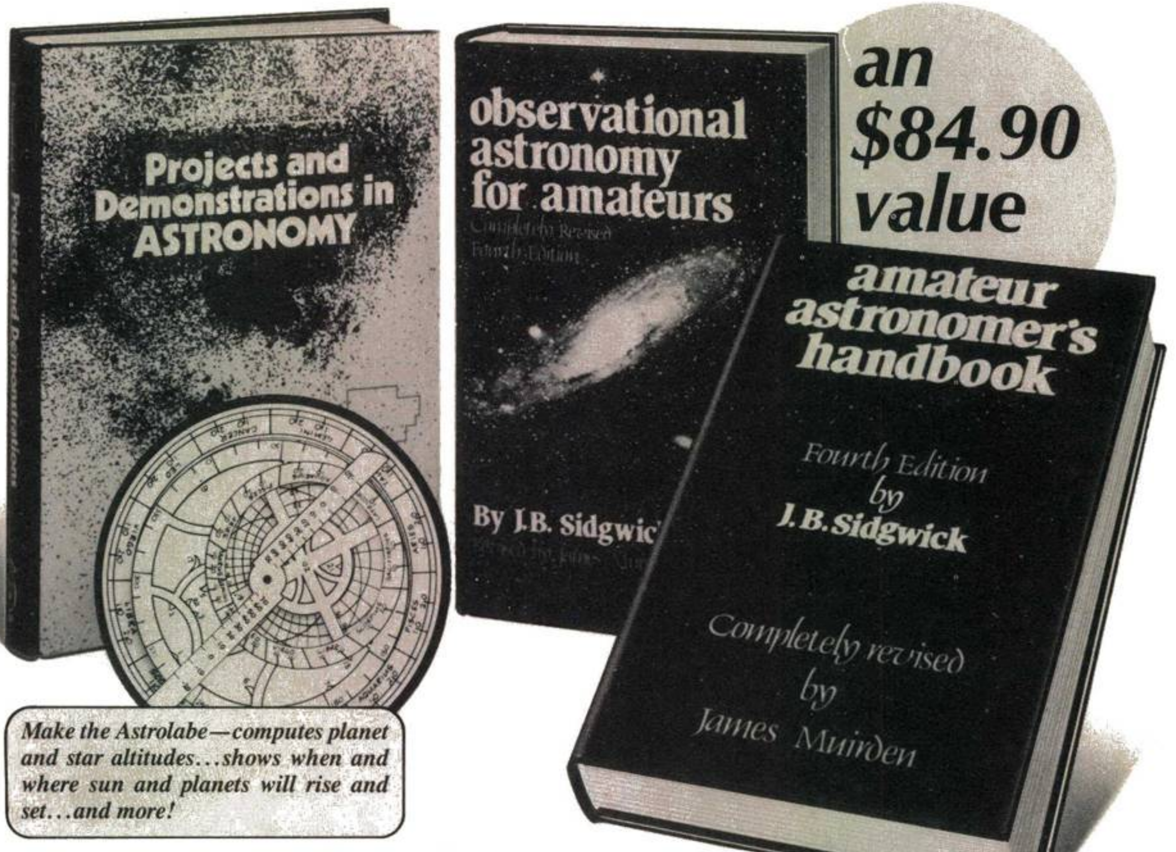
In the midst of this fertile land of John Deere tractors, Goodyear Tire dealerships, Hi-Gro fertilizer, and Pietsch Hybrid Corn lies Peoria. The city rises from the west bank of the Illinois River, the cluster of downtown buildings shimmering in late afternoon haze. I found the convention hotel easily, got my room key, then — boom — in the lobby recognized the familiar face of Bob Cox, the Associate Editor for *Telescope Making*. The pre-registration packet for ALCON had been immensely complex with many separate sheets to fill out, but it made checking in simple. Hats off to the organizing committee.

Bob, his wife Hilda, and I had a fine dinner at a restaurant right by the river — a converted railroad station — and talked about the telescopes we had seen and the people we'd met at the Texas Star Party (which he went to) and the Riverside Telescope Makers Conference (which I attended). There always seems to be a lot of that sort of talk when amateur astronomers get together.

The Astronomical League dates back to 1939, when members of eleven astronomical societies met in New York City to discuss forming an national organization of amateur astronomers — but World War II intervened. The League incorporated in 1947, and today roughly 160 astronomical societies and clubs belong to it. The League consists of nine "Regions" which conduct their own activities and also hold annual regional conventions. Membership ($15 plus 96 cents per member per year for each club) brings a variety of League services and the *Reflector* newsletter. It also brings what I think is the most valuable service the League can offer: personal contact with more amateur astronomers and astronomy clubs.

So it was that on Thursday, July 22, at 9 a.m., the 36th National Convention got under way. Georgia Sutherland, the convention chairman, called the delegates to order. She introduced Eric Clifton, president of the Peoria Astronomical Society, the club which hosted this year's event, then R. P. "Van" VanZandt, a past president of the League — a real spark in the Peoria group. Van is the author of many of the League's "Observe" manuals.

Introductions and words of welcome continued with Orville Brettman, 1982's League president; Roger Kohlman who runs the


an $84.90 value
Projects and Demonstrations in ASTRONOMY
observational astronomy for amateurs
By J.B. Sidgwic
amateur astronomer's handbook
Fourth Edition by J.B. Sidgwick
Completely revised by James Muirden

Make the Astrolabe—computes planet and star altitudes...shows when and where sun and planets will rise and set...and more!

Take this 3-volume Amateur Astronomer's Library for $2.95

as a member of Astronomy Book Club

You simply agree to buy 3 more books—at handsome discounts—in the next 12 months.

Assembled *especially* for the serious amateur astronomer, this 3-volume collection covers everything from obtaining the clearest image of Mars to equipment for celestial photography, from constructing the orbit of a comet to determining the latitude and longitude of Saturn.

Here's what your Library will include:

PROJECTS AND DEMONSTRATIONS IN ASTRONOMY. *Donald Tattersfield.* An introduction to the mechanics of the universe. Investigate celestial phenomena in dozens of projects using nothing more complicated than a pair of compasses, a protractor, and a set square. A personal sourcebook for study of celestial phenomena—from solar and lunar eclipses to the motion of the planets to the brightness and magnitude of the stars. Over 60 weatherproof projects. Publisher's Price $39.95.

OBSERVATIONAL ASTRONOMY FOR AMATEURS. Fourth Edition. *J. B. Sidgwick. Revised by James Muirden.* One of the most popular sky handbooks ever published has now been extensively revised and up-dated for the amateur astronomer of the '80's. With even a modest aperture telescope, you can discover the wonders of the cosmos as each chapter focuses on a particular object—from the Sun, Moon, planets, asteroids and comets to the distant stars. *The practical basics that turn the beginner into the knowledgeable observer.* Over 350 pages. With a new 40-page bibliography. Fully illustrated. Publisher's Price $19.95.

AMATEUR ASTRONOMER'S HANDBOOK. Fourth Edition. *J. B. Sidgwick. Completely revised by James Muirden. The* classic guide for stargazers—extensively revised and up-dated—provides authoritative advice on telescopes and their accessories, and useful data on practical observation through mathematical computation. A special section new to this edition reviews techniques and apparatus for astronomical photography including use of binoculars and special filters. Over 570 pages. Profusely illustrated. Publisher's Price $25.00.

4 Good Reasons to Join

1. The Finest Books. Of the hundreds and hundreds of books submitted to us each year, only the very finest are selected and offered. Moreover, our books are always of equal quality to publishers' editions, *never* economy editions.

2. Big Savings. In addition to getting the AMATEUR ASTRONOMER'S LIBRARY for only $2.95 when you join, you keep saving substantially—up to 30% and occasionally even more. (For example, your total savings as a trial member—including this introductory offer—can easily be over 50%. That's like getting every other book free!)

3. Bonus Books. Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings up to 70% off the publishers' prices.

4. Convenient Service. At 3-4 week intervals (16 times per year) you will receive the Book Club News, describing the Main Selection and Alternate Selections, together with a dated reply card. If you want the Main Selection, do nothing and it will be sent to you automatically. If you prefer another selection, or no book at all, simply indicate your choice on the card, and return it by the date specified. You will have at least 10 days to decide. If, because of late mail delivery of the News, you should receive a book you do not want, we guarantee return postage.

Astronomy Book Club is a very special club—one that is operated exclusively for astronomy enthusiasts. The Club is devoted to making the finest astronomy books available conveniently and inexpensively!

Astronomy Book Club L-AS5
Riverside, New Jersey 08075

Please accept my application for trial membership and send me the AMATEUR ASTRONOMER'S LIBRARY (10190) for $2.95. I agree to purchase at least three additional Selections or Alternates over the next 12 months. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three books. A shipping and handling charge is added to all shipments.

No-Risk Guarantee: If you are not satisfied—for any reason—you may return the AMATEUR ASTRONOMER'S LIBRARY within 10 days and your membership will be canceled and you will owe nothing.

Name ______________________

Address ______________________

City ______________________

State ______________ Zip ________

(Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)

League's subscription service (members of the League, incidentally, may receive a discount subscription to ASTRONOMY as a benefit of membership); and Barry Beaman, president of the League's North Central Region, who admitted, "even though I'm from Rockford, I like Peoria" — shades of a traditional rivalry.

Several other national groups held their meeting in conjunction with the League this year, so their representatives also welcomed us. Walter Haas, director of the Association of Lunar and Planetary Observers, or ALPO, "which has nothing to do with the dog food company that 'stole' our abbreviation"; the IAPPP, a group of both amateur and professional photoelectric photometrists; Bert Stevens of IOTA, the International Occultation Timing Association; and Alan Goldstein, the national coordinator of the NDSOS (National Deep Sky Observer's Society). The morning had become something of a "Who's Who" in amateur astronomy.

The first speaker of the meeting was billed as "a local Peoria boy," Dr. Michael Davis, now grown up and today the radio astronomer in charge of the 1000-foot dish at Arecibo, Puerto Rico. His father, a member of the Peoria Astronomical Society, introduced him. Dr. Davis spoke on the large-scale structure of the universe, his current field of research, lucidly explaining the problem of producing large-scale inhomogeneities we see today (super groups of galaxies) from the extremely homogenous cosmic fireball we observe via the microwave background radiation. This was the kind of talk that makes the hair on the back of your neck stand up!

His talk was followed, after a short break, by a history of the Peoria Society's Jubilee Observatory, given by Eric Clifton. I hoped that the sky would clear up — the observatory was something I didn't want to miss — but at noon, it was still cloudy and looked like rain.

One of the attractions of meetings such as ALCON are "paper" sessions, where various speakers present observational results, discuss techniques, or show pictures. The afternoon paper session was devoted to papers by ALPO members. I particularly enjoyed the paper on the 1981-82 apparition of Mars by Donald Parker, a frequent photo contributor to ASTRONOMY's Backyard Astronomer department, and one by Walter Haas on the naked-eye visibility of the satellites of Jupiter.

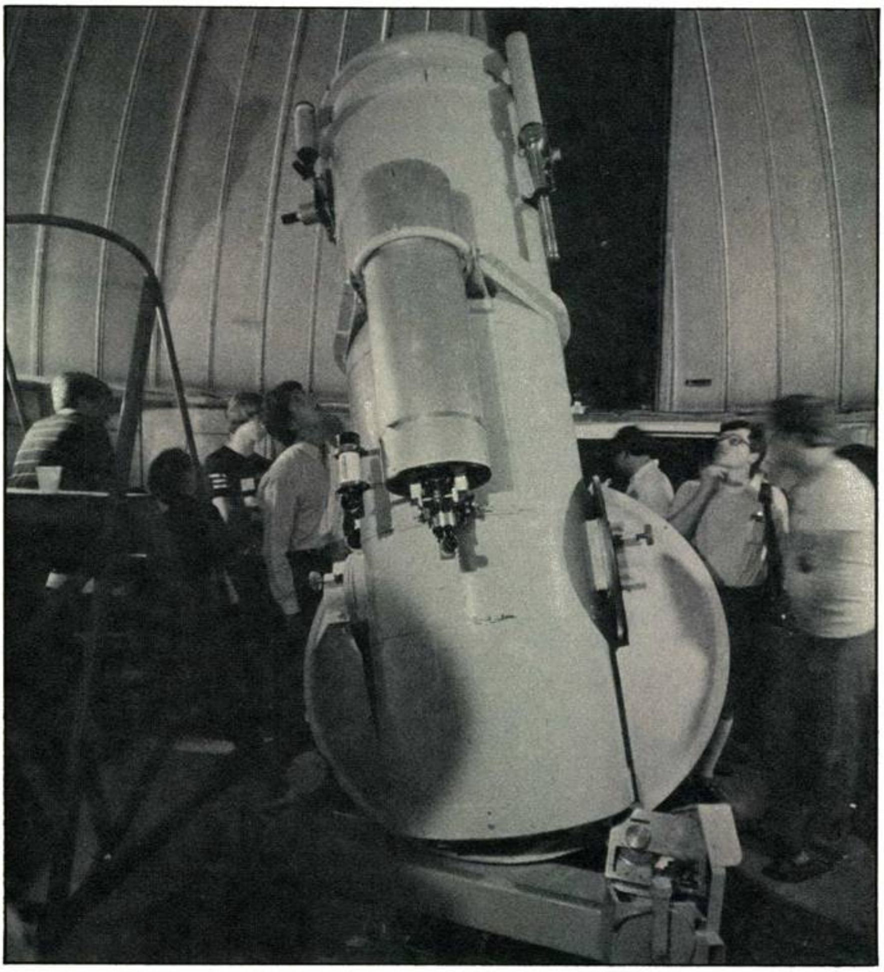
During the paper sessions it rained, but the sky cleared afterward. That evening after dinner, I hopped aboard one of the shuttle buses taking conventioneers some 20 miles west of Peoria, away from the lights, to Jubilee Observatory. We arrived as it was getting dark. Jupiter, Saturn, Mars, Spica, and a thin lunar crescent hung in the western sky.

The observatory's main attraction is the 24-inch Newtonian reflector. Now nearly complete, this massive instrument rides in a huge horseshoe type mounting made of two steel cones, and is driven by the rollers it rests on. It is housed in a concrete silo block building with a metal dome. Jubilee also features a 14-inch reflector in another dome about the same size, a portable 10-inch, and plenty of members' telescopes. One member, Art Grebner, the man who ground and figured the mirror in the 24-inch telescope, had set up a portable 20-incher on the grass near the dome of the main scope.

I had expected lines, but when there was a line, it was short. It never took more than two or three minutes to reach the eyepiece for a view of M-51 and its spiraling arms, the rich starry core of M-13, or the greenishly glowing Ring Nebula, M-57. These are fine sights in a 24-inch telescope under a good sky.

It was pretty late when the last busload of conventioneers finally left the observatory. Getting up the next morning for the first item on the agenda, "The Group Photograph," was not easy. I joined several hundred amateurs milling around the front of the hotel, and we stood obediently on the hillside, did not allow anyone else to obscure us, smiled, and had our picture snapped.

The annual business meeting followed with reports on the League's functioning by committees and the League's officers. As of Friday morning, they reported, there were 230 registrants, with representatives from every region. Orville Brettman noted that the League had lost a few clubs last year but also gained a few, most notably two in California, a part of the country where the League has traditionally been weak. He also stressed the need for cooperation with the Western Amateur Astronomers, a California organization somewhat like the League. The League now maintains a library of computer programs to loan to members. That particularly



The Peoria Astronomical Society's 24" reflector rides in a massive mounting.

SAVE $150.00

Edmund Scientific 8-Inch f/5 Telescope System

Reg. $899.00 NOW ONLY **$749.00**

Now the excellence you've come to expect from Edmund Scientific costs less. You already know our 8-Inch f/5 Telescope is an exceptional deep sky instrument. At a savings of $150, it's even a greater astronomical value! This scope offers a three point adjustable primary mirror cell & a fully adjustable secondary mirror cell with patented 0.005 in. supporting vanes to maintain optical alignment. It offers views from rich field to diffraction limited high resolution. The Newtonian system minimizes aberrations common to compound optics systems without sacrificing the superb light-gathering ability. Sturdy construction allows the Edmund 8-Inch f/5 to "damp out" faster than other telescopes. Comes complete with setting circles on both axes, fine adjustment declination control, a hysteresis synchronous motor drive, a 2 in. focuser and an impact resistant ABS plastic tube. The lightweight Equatorial Fork Mount delivers remarkable stability, uncommon portability and easy access to any part of the sky. To order your 8-Inch f/5 Telescope, call **Toll Free 1-800-257-6173.** In New Jersey, dial 1-800-232-6677. For additional information on the 8-Inch f/5 Telescope, ask for Bill Shonleber.

101 E. Gloucester Pike, 8211-K22
Barrington, N.J. 08007

Unique LUMICON Telescopes & Accessories For Deep Sky Exploration

Authorized Celestron, Meade Dealer

★World Center for Astrophotography★

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All LUMICON EASY-GUIDER™ off-axis guiders have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright-guide stars. SPECIFY CAMERA AND TELESCOPE TYPE:

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in secs. Specify 2" or 1¼".
NEWTONIAN EASY-GUIDER™ **$139.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation - 3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER™ **$199.50**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination and pinpoint star images. F-ratio adjustable f/4-f/11. **Also yields unmatched rich field viewing.**
GIANT EASY-GUIDER™ **$359.50**

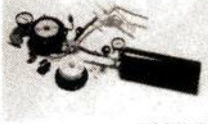
48mm DEEP-SKY Filter™ ordered with any EASY-GUIDER™[SAVE $30] **$59.95**

FILM HYPERSENSITIZATION KITS

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe and simple to use. Each HYPER-KIT™ includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas and hand-operated vacuum pump.

MODEL 100 HYPER-KIT™ for 35mm film rolled-up. TAKES LONGER, but is easy to use. Not recommended for 2415 .... **$215.00**

MODEL 300 HYPER-KIT™ sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$265.00**



MODEL 600 HYPER-KIT™ [see photo]. Like the model 300. but also sensitizes 120/220 larger format film and small glass plates.................. **$289.50**

MODEL 1200-HYPER-KIT™ is for 4 X 5" plates and film up to 5 X 7". Has 2 gas cylinders and includes temperature controller **$499.50**

Temperature controller for any HYPER-KIT™ **$49.50**

Electric Vacuum Pump...................... **$265.00**

FILTERS PIERCE SKYGLOW

The LUMICON DEEP-SKY Filter™ improves both visual and photographic contrast on all deep-sky objects, including galaxies. The LUMICON UHC Filter™ is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	UHC	Deep-Sky
For 1¼" eyepieces	**$69.50**	**$59.50**
48mm, for 2" eyepieces	**$99.95**	**$89.50**
For 2" eyepieces and photography		**$99.50**

H-ALPHA PASS FILTER

Yields spectacular contrast gains in black and white photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

SPECIFY LENS SIZE.	H-Alpha	(MV)
46, 48, 49mm	**$29.95**	**$25.00**
52, 55, 58, 62mm	**$39.95**	**$29.95**
67, 72, 77mm	**$46.95**	**$39.95**
82mm	**$49.95**	
Hypered 2415 film, 36 exp	**$9.95**	3/**$26**

LUMICON, Dept. A3, 2111 Research Drive #5, Livermore, California 94550
Complete Catalog $1 *"Staffed by Experienced Astonomers"* [415] 447-9570

interested me — a sign that the League is keeping up with the times.

But as I listened, I noticed that white-haired heads dominated the audience. The League, at least as represented at its national convention, seems to be an aging organization. However, a mid-week convention is by far most accessible to people who are retired, while many younger members who would like to have attended probably could not. The League today, far from being an organization devoted to dwelling in its past, demonstrates a certain vitality especially evident in the last three or four years.

It's nice to look over all the merchandise and see what it looks like.

We listened to lots more papers in Room C, viewed plenty of "Astro-Art" and "Astro-Photo" exhibits in Room 4, and drooled over the commercial and group exhibits in Room 3. I looked over the wide selection of digital setting circles, solar filters, eyepieces, finders, binoculars, focusers, then the booklets, tee shirts, and observing aids sold by the League. A 6-inch apochromatic refractor and Maksutov catadioptric were on display along with magnificent planet drawings by ALPO members, paintings, cartoons, a solar system wall hanging, and even parti-colored sewn and stuffed planets!

The afternoon papers, in a session presented by the IAPPP, were particularly interesting to me. Photoelectric photometry, of all the areas where amateur astronomers can do useful scientific work, has finally come of age. With a coterie of professional astronomers, the most outstanding of whom is Douglas Hall from Vanderbilt University, amateurs can make measurements that have immediate scientific interest. Dr. Hall spoke on new variable stars recently discovered by amateurs, then Orville Brettman and Bill DuVall of the Racine Astronomical Society reported on two stars, one now known to be variable, the other now known NOT to be variable. Russ Genet, founder of the IAPPP, spoke on his own 16-inch telescope, its observatory, and computer controlled photometer — but he was quick to point out that photoelectric photometry can be done with amazingly modest equipment.

On Friday afternoon, the sky was still clear, so it looked good for another evening at the observatory. I joined the afternoon tour of Wildlife Prairie Park, where all types of Great Plains animals are on display in approximations of their native habitats, and herds of buffalo, deer, and antelope roam. After the tour, the park people served us a barbeque dinner complete with apple pie.

At Jubilee that night, there may have been four times as many people, but there were also four times as many telescopes. I enjoyed crisp views through an apochromatic 4-inch refractor, the Chicago Astronomical Society's magnificent and solid 12-inch Dobsonian reflector, an achromatic 6-inch folded refractor, and the 24-inch telescope — this time through an ultra-wide-angle eyepiece. What a view M-13 made! The combination of big aperture and super-wide view made looking not like peering through a porthole, but like being there, hanging in space! Once again, I ended up on the last bus back.

Saturday morning's first speaker was Philip Jose Farmer, a well-known science fiction writer who lives in Peoria. He spoke on "How to Build a Planet," and engagingly described Riverworld, the planet he has created in his writings. There were more papers, special workshop sessions on telescopes, photometry, planetary observing, and cosmology, the Telescope Fair in the main ballroom, and lots of "just plain talking" — so many things that no one person could have done them all. But I cut my afternoon short and went back to my room — I needed a nap after two late nights.

The final evening brought us to what was undoubtedly the main event — the banquet. It featured planet hunter Clyde Tombaugh speaking on his discovery of Pluto. We ate, we listened, we applauded as the convention honored those people who had worked to bring us together and had shared with us the fruits of their effort. Bob Cox was honored with a special award for excellence in telescope making, and

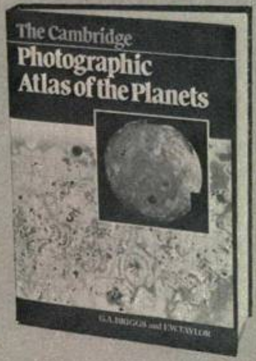
Astronomical Society
STARGAZER
Dean Meyer stands beside the Chicago Society's solid 12½" f/5 Dobsonian.

ASTRONOMY Bookshelf

The Cambridge Photographic Atlas of the Planets

Geoffrey Briggs and Fredric Taylor

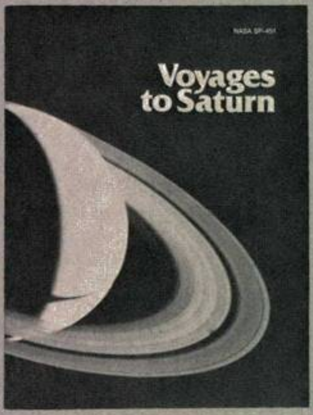
In the last 20 years, planets as distant as Saturn and satellites as near as our Moon have been "seen" by robot spacecraft and orbital and flyby probes. This colorful, large-format book reproduces over 200 of the space photographs that have revolutionized our view of the solar system. Detailed maps and an authoritative text complete the **Atlas** — you won't find a better reference book, or a finer starting point for armchair space-travel!


The Cambridge Photographic Atlas of the Planets
G.A. BRIGGS and F.W. TAYLOR

225 pages, hardcover, **$25.50**

Voyages to Saturn

David Morrison



A member of the Voyager imaging team and leading planetologist, David Morrison relates the exciting story of the two Voyager encounters with Saturn. Follow the encounters day-by-day and peek over the scientists' shoulders to discover what they learn about Saturn. **Voyages to Saturn** puts you at JPL as the historic events happen. Profusely illustrated in color.

277 pages, paperback, **$11.95**

Also Available . . .

Rand McNally's New Concise Atlas of the Universe: Moore. Large-format guide to the sky with almost 1000 photos, 400 in full color. 190 pages, hardcover, $36.50.

Planets of Rock and Ice: Chapman. Travel from the Sun-scorched wastes of Mercury to the chilly balls of ice that circle Saturn. On the way, learn what planetary science tells us about our own planet, Earth. 222 pages, hardcover, $14.50.

Celestial Objects for Common Telescopes: Webb. Volume 1 is about the solar system; volume 2 covers all else, constellation by constellation. 606 pages in all, paperback, $11.00 (set).

Concise Book of Astronomy: Mitton & Mitton. Intended for newcomers to the subject, this book is simply written and colorfully illustrated. 96 pages, hardcover, $13.50.

The Big Bang: Silk. How the universe began and how it has evolved over the eons: the intriguing and at times bizarre story of cosmology. 394 pages, paperback, $10.50.

Out of the Darkness: The Planet Pluto: Tombaugh & Moore. The absorbing story of how the 9th planet in the Sun's family was found — told by its discoverer! 221 pages, hardcover, $15.50

Facts on File Dictionary of Astronomy: Illingworth. Astronomical terms and abbreviations covering the range of astronomy from observing to astrophysics — the entries range from simple definitions to mini-essays. 378 pages, hardcover, $18.00.

Atlas of Mercury: Moore & Cross. Detailed maps and Mariner 10 photos of the elusive planet as well as historical and scientific facts. 48 pages, hardcover, $10.95.

The Moon: Moore. Provides a detailed look at the lunar surface as seen from Earth — and from the vantage point of the astronauts who walked on it. 96 pages, hardcover, $15.50.

Star Names: Their Lore and Meaning: Allen. The classic source for the legends behind star names and constellations as well as other celestial folklore. 563 pages, paperback, $6.50.

The Unfolding Universe: Moore. Surveys the extraordinary changes the past quarter century has brought to astronomy — a colorful and informed retrospective of a fascinating period. 256 pages, hardcover, $18.50.

Astronomical Companion: Ottewell. Large-format book that provides a wealth of background information on astronomy. 73 pages, paperback, $12.50.

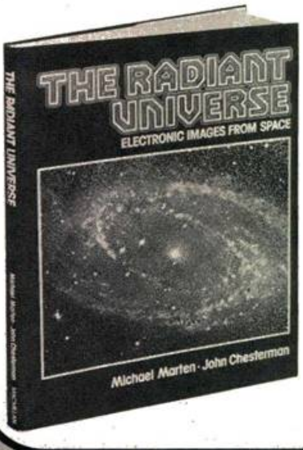
Cambridge Encyclopaedia of Astronomy: Mitton. Authoritative survey of every aspect of modern astronomy — our solar system, stars, galaxies — all about the incredible universe we inhabit. 481 pages, hardcover, $41.50.

Whitney's Star Finder, 3rd ed.: Whitney. Find the stars, constellations and planets with this classic field guide — also forecasts the major celestial events through 1985. 102 pages, paperback, includes a planisphere, $9.50.

Burnham's Celestial Handbook: Burnham. The great modern classic about deep-sky objects; arranged by constellation, it covers the whole sky in 3 volumes. 2138 pages in all, paperback, Vol. 1 - $9.50; Vols. 2 & 3 - $10.50 each.

Jupiter: Hunt & Moore. Shows what the Pioneer and Voyager probes imaged with their computer-cameras, and what the backyard telescope reveals. Also features detailed maps of the 4 Galilean satellites. 96 pages, hardcover, $15.50.

Cosmos: Sagan. A lucid, colorful and exciting print version of Carl Sagan's acclaimed public television series. 365 pages, hardcover, $23.50.


THE RADIANT UNIVERSE
ELECTRONIC IMAGES FROM SPACE
Michael Marten · John Chesterman

November Special:

The Radiant Universe

Price: $15.95

The Radiant Universe: Marten & Chesterman. Colorful computer-enhanced space photographs and satellite scans reveal our surroundings in new ways. View distant galaxies, the Sun, our neighboring planets, as well as continents and cities on Earth in electronically amplified detail. 128 pages, hardcover, **$15.95. Order by Nov. 30!** (Regular price: $18.50).

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

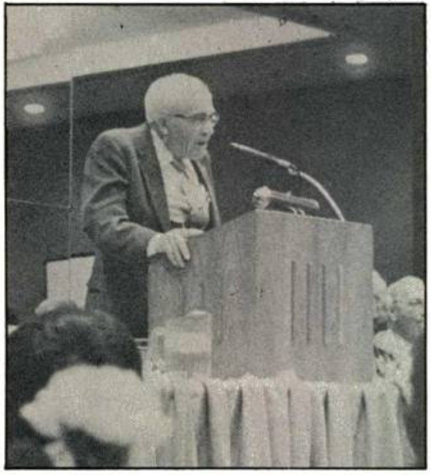
the League's Leslie C. Peltier Award for observations of lasting impact on astronomy went to Walter Haas, the director of ALPO.

Then it was Walter Haas's turn to honor Clyde Tombaugh, introducing him as not only the man who discovered Pluto, but also one of the first astronomers to apply geological thinking to the surface of Mars, the man who planned the first regular photographic survey of the planets, and also "absolutely the worst punster west of the Pecos."

"Ladies and gentlemen," said Dr. Tombaugh with a wicked little grin, "I have a confession to make. For 52 years, I have been a Plutocrat," — and we were off to a running start. "If you'll read my book, you'll learn all sorts of things that can't be told in scientific papers," he said, relating how he had been hired as a raw young amateur astronomer, and shortly afterward began the search for Pluto. "After I had blinked about two photos," he said, "I realized we were in very serious trouble."

With 400,000 stars per plate, only a very carefully controlled program producing closely matched plates taken at the right times could hope to distinguish a trans-neptunian planet from the hordes of asteroids. It was Clyde Tombaugh who supplied that careful control. Less than a year later, the young astronomer walked into his boss's office and, trying to be as nonchalant as possible, quietly announced, "Dr. Slipher, I've found Planet X."

After finding Pluto, Tombaugh spent years searching the sky for other planets, thus placing severe constraints on the search for Planet Ten, now rapidly becoming an important research problem since Pluto cannot account for perturbations seen in the orbits of the outer planets. I think everyone felt that they had heard a great man talk as they left the banquet.



Fifty-two years ago, Clyde Tombaugh found Pluto.

There were buses to Jubilee again that night, but I chose to go to the other Peoria observatory, the old observatory, located on the Northmoor Golf Course, and featuring a 9-inch refractor. Northmoor is open to the public every Saturday from May through October. If you live near Peoria, go to it some night; it's a wonderful place.

When we arrived, the public star party was still going. There were about two dozen people: teenage couples, parents with kids, a few conventioneers. I got in the line to look, but ended up showing visitors Jupiter and Saturn!

Old refractors have an incredible charm, but this one has a rock-solid mounting and superb optics, too. It split a star with 0.9 second of arc separation with no trouble at all, and both Jupiter and Saturn, though very low in the sky, were impressive. The two hours I spent there seemed only half that long — but by 12:30, I was exhausted.

Driving back to Milwaukee the next day, I reflected on ALCON 82, and the fact that the whole thing was put on by a bunch of people who are in it only to help other people, to make astronomy and its wonders available to everyone. That's a fine thing to be doing.

— *Richard Berry*

A Westerbork Decade

Perhaps as compensation for living in a tiny country, the Dutch have a remarkable interest in the vast reaches of the cosmos — and it seems to have long been that way. Starting with Huygens in the 17th Century, the history of astronomy contains a disproportionate number of solid Dutch names: Bok, van den Bergh, Kapteyn. Now the same is happening for the first offspring of classic astronomy: radio astronomy.

In the last dismal year of the Second World War, when Dutch academic life had largely gone underground, a young astronomy student in Leyden predicted that the neutral hydrogen atom would emit a special radio frequency. The student is now Professor van der Hulst, and his special radio frequency, which was confirmed a few years later, is the familiar 21-cm wavelength hydrogen line.

This single radio frequency is crucial to astronomy because neutral hydrogen clouds constitute about half of the matter in the universe. You might say that before the 21-cm line, astronomers could see only half the universe!

Unlike another pioneer in radio astronomy, radio engineer Grote Reber, van der Hulst and his teaching professor Jan Oort did not sink into oblivion. Using German war surplus "Wuerzburg" aircraft interception radar dishes, they started experimenting after the war and together with investigators at Harvard and in Australia showed that the theoretical prediction was indeed correct. Their scientific standing — plus some intensive lobbying — finally got them a 25-meter dish at Dwingeloo which, in 1957, was the biggest in the world. This instrument contributed to the international research program that finally showed that we live in a spiral galaxy.

In science, results are the only thing that count. And the undeniable results obtained at Dwingeloo were so important that van der Hulst and company soon had funds for a much bigger instrument to be erected nearby. That instrument was the Westerbork aperture synthesis radio telescope — a mile-long row of twelve 25-meter dishes. It started work in 1970, and before the decade was out, was expanded to fourteen dishes forming a baseline of 3,000 meters.

Who uses Westerbork? Primarily, the instrument was intended as a tool for scientists from the Dutch universities at Groningen, Leyden and Utrecht. In addition, astronomers from other countries may request observation time, as many American astronomers have. The Dwingeloo-Westerbork organization also includes a team of in-house astronomers.

While sniffing around at Dwingeloo and Westerbork, I made a fascinating discovery: scientists are not at all slotted into pigeonholes according to their training. The boundaries in science are fluid — and versatility is a necessity. The most striking example is H.C. Kahlmann, head of the telescope group, and in charge of the operation of this multi-million guilder radio telescope. His original scientific education was in geophysics, and for several years he worked in the oil industry. Well, in an astronomical sense, Westerbork and Dwingeloo have struck oil many times.

"The instrument is so complex," says Kahlmann, "that most astronomers do not even visit us to make their observations. They

Atlanta's First
and the Southeast's
Largest Dealer

Name Brand Telescopes
and Accessories Available

DIXIE TELESCOPES

290 Hilderbrand Dr., Suite B-8, Atlanta, GA 30328

Come visit our Showroom — hours: 10-6 Mon. - Sat.
Phone: (404) 256-STAR

LOWEST TELESCOPE PRICES IN THE SOUTH

We will match the advertised price of any dealer, anywhere!

- **Celestron C8 with field tripod, equatorial wedge, eyepieces, *complete*, $995!**
- **Meade 2080 with field tripod, equatorial wedge, eyepieces, *complete*, $995!**
- **NEW Meade 10" Model 2120 Schimdt-Cassegrain, $1,695!**
- **Celestron C11, $2,450! Celestron C14, $4,995!**
- **Edmund Astroscan 2001, $195.46, free shipping!**
- **Tele Vue Plossl Eyepieces, 10% discount when ordered at the time of purchase of any telescope, or receive a deluxe eyepiece carrying case when you purchase a set of four or more.**
- **Complete Optical Craftsmen 8" f/6 Newtonian telescope with clock drive, setting circles, and eyepieces, $569.95.**

We have dozens of discounts for many fine products by: Meade, Celestron, Edmund, Tele Vue, Brandon, Optical Craftsmen, University Optics, Novak, Lumicon, Star-Liner, Abraxas, Unitron, Parks, Astro-Physics, Questar, Swift, Telescope Systems, DayStar, Rudy E. Kokich, AccuTrack, and many others! Write for our free discount catalogue.

Dixie Telescopes will sell your USED telescopes, accessories, books, etc. Send S.A.S.E. for our Used Equipment List.

We also buy, sell, and trade Alvan Clark Refractors, any size or condition. $500.00 cash paid per inch of aperture!

The Bowl of Night

A HAND-CRAFTED THREE DIMENSIONAL PLANISPHERE FOR VIEWING THE NIGHT SKY

The BOWL OF NIGHT™ is a desk top planisphere, that solves the ancient problem of accurately representing the night sky. The vault of the heavens is more obvious than on any flat sky map. Skywatching is fun when you can understand how celestial objects move. By turning the opaque horizon hemisphere inside the blue bowl of stars, you can display the night sky for any hour of the night, any time of year. The BOWL OF NIGHT™ comes with an instruction pamphlet and is 14½" in diameter, made by SPHERICAL CONCEPTS, INC., the exclusive licensed manufacturer of the orignal BOWL OF NIGHT.™ *Patent pending.

Another Hand-crafted Creation of **Spherical Concepts, Incorporated** 941 Parkview Drive King of Prussia, PA 19406 Telephone: 215:783-0272 Makers of **Spheres of Influence®**

To: **Spherical Concepts, Inc.**
941 Parkview Drive
King of Prussia, PA 19406

Bowl of Night™
— $65.00 ea.

Please send me ______ BOWL(s) OF NIGHT™ with instruction pamphlet(s). If I am not completely satisfied I may return my BOWL(s) OF NIGHT™ within thirty (30) days and receive a complete refund. Enclosed you will find my check for ______ plus three dollars ($3.00) for shipping and handling or bill by VISA/MASTERCHARGE card.

VISA/MASTERCHARGE
Card # ______ **exp. date** ______
Name ______
Address ______
City ______ **State** ______ **Zip** ______

ECLIPSE '83 EXPEDITIONS

A Choice of Two Scientific/Cultural Expeditions Featuring the Total Solar Eclipse of June 11, 1983

The Far East
May 29-June 13, 1983
16 Exotic Days Exploring
Hong Kong - Bangkok
Singapore - Jakarta
and Bali
All Inclusive...$3395

The South Pacific
May 29 - June 14, 1983
17 Exciting Days Exploring
Auckland - Rotorua
Sydney - Melbourne
Jakarta and Bali
All Inclusive...$3495

Photo Courtesy of Allen Seltzer

These Two Deluxe Tours Will Include...

•Top Hotels In Each City • Breakfast And Dinner Daily •Cocktail Reception • Gala Welcome Dinner •Eclipse '83 Celebration Banquet • Guided Sightseeing • All Travel By Jet And Deluxe Motorcoaches • Fully Escorted • All Transfers, Taxes, Tips And Porterage.

Featuring An All-Star Cast Of Guest Lecturers...

Dr. George O. Abell, Author and Professor of Astronomy at UCLA; **Richard Berry,** Author, Photographer and Editor of *Astronomy* Magazine; **Dr. Mark R. Chartrand III,** Executive Director of the National Space Institute; **Barry Gordon,** Lecturer in Astrophotography at Hayden Planetarium; **Dr. Karl G. Henize,** Astronomer/Astronaut with NASA and Professor at the University of Texas; **Dr. Edwin C. Krupp,** Director of the Griffith Observatory, Lecturer at UCLA and Author; **George Lovi,** Authority on Star Identification and an Editor at *Sky & Telescope Magazine;* **Allen Seltzer,** Director of the Hayden Planetarium; **Dr. Lee W. Simon,** Director of the Morrison Planetarium.

INTERNATIONAL SEMINAR PROGRAMS
SUITE 100, 645 EAST PARK AVENUE
LONG BEACH, N.Y. 11561 516/432-1991
TOLL FREE: 800/645-2510

YES. We are interested in the Eclipse '83 Expeditions. Send us full details.

Name ______
Address ______
City ______ State ______ Zip ______
Telephone: Home ______
Business ______

specify what they want to have observed, and like a mail-order firm, we send them the tapes with data. This is not an ideal situation, but it has evolved that way. Also, we are usually unable to tell an astronomer at what precise moment his data will be gathered: our schedule is made at the beginning, but is continually altered because problems in other programs may upset planning. There is no time left for improvising. The demand is still more than double the total time available!"

From the outset, four countries have dominated the field of radio astronomy. Two are large, populous countries: the U.S. and Great Britain. The other two, Australia and Holland, have no more than about 14 million people each. Yet both decided to invest heavily in the esoteric realm of radio telescopes.

"But a radio telescope is a very sensible investment," Kahlmann points out, "because you can continue to improve it. Take the hardware we have. We've doubled the baseline — a spectacular operation. The two additional dishes had first been in operation near the other 12 for two years. In this manner a number of weak objects that are rather extended were examined with maximum sensitivity. When that program was done, those two dishes were lifted and moved a mile to double the baseline." A nightmarish operation, hauling that heavy and ultra-precise radio telescope through the Dutch countryside. As better receivers are developed, they can simply be added to the telescopes.

But much can be done in software too. The Westerbork array operates under computer control, so it would be possible for one half of the instrument to do one thing and the other half something entirely different, simultaneously.

In view of the complexity of the equipment, the in-house astronomers have an important function in dealing with the wishes of outside astronomers and the equipment's capabilities. Dr. Richard Strom, a second generation Norwegian of U.S. nationality who studied at England's Jodrell Bank, did post-doctoral work in Leyden, and now works in Dwingeloo — all the while speaking fluent Dutch — is in charge of this team. Who could better assess the Dutch role in radio astronomy?

"The scientific climate in the country is stimulating," Strom says unhesitatingly. "One of the reasons is the very large number of scientists from other countries visiting here. At Jodrell Bank, for instance, international contacts are much rarer. In addition, Jodrell Bank has the tradition of being a radio observation station. The consequence is that you see radio astronomers there, but few astronomers."

It is a typically Dutch phenomenon, says Strom, "based on the solid tradition that those teaching astronomy aim at giving a student the broadest background possible. In other countries, radio astronomers and optical astronomers tend to go their separate ways, but here there is a sound common base to communicate on."

One important field of research, Strom thinks, is spectral line work — to obtain a better insight into the dynamics of distant galaxies and into the nature of objects in our own. Talking about past achievements and future plans, Strom again stresses the importance of versatility.

"Astronomy is an extreme form of physics. Things happen in the cosmos that are impossible in the laboratory. The greatest value of astronomy is that it repeatedly forces you to rethink everything."

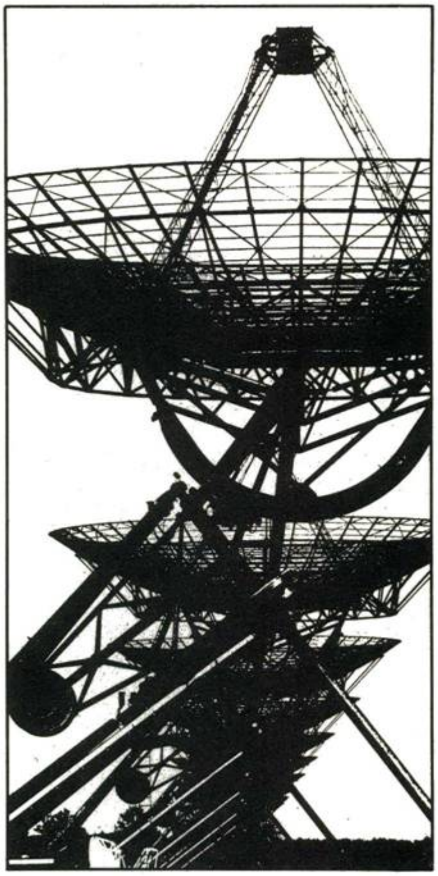
"Take irregular galaxies like the 3C-129 tadpole. The proliferating number of 'peculiar' galaxies discovered raises the question 'how peculiar is peculiar?' Or take 3C-236, the biggest object in the universe, and one of the more spectacular discoveries we've made here. It looks quite ordinary and would be regarded as just one more double radio source until you know its distance! How better to stress the importance of correlation with optical astronomy?"

Surveying achievements during the first decade in Westerbork, Dr. Kahlmann remarks that feedback is not too frequent. "When 3C-236 was published, the observations were very much history for us. If a scientist finds something of that order of oddity, his first reaction will be, 'I don't believe that.' So he has to go back and check, seeking confirmation, which takes a lot of time. Every day we discover scores of spectacular novelties most of them artifacts."

"In addition," Kahlmann says of the pace of discoveries, "I can't even keep up with papers based on observations made here. I am much too busy with new requests for observation time and plans for the future to read them all."

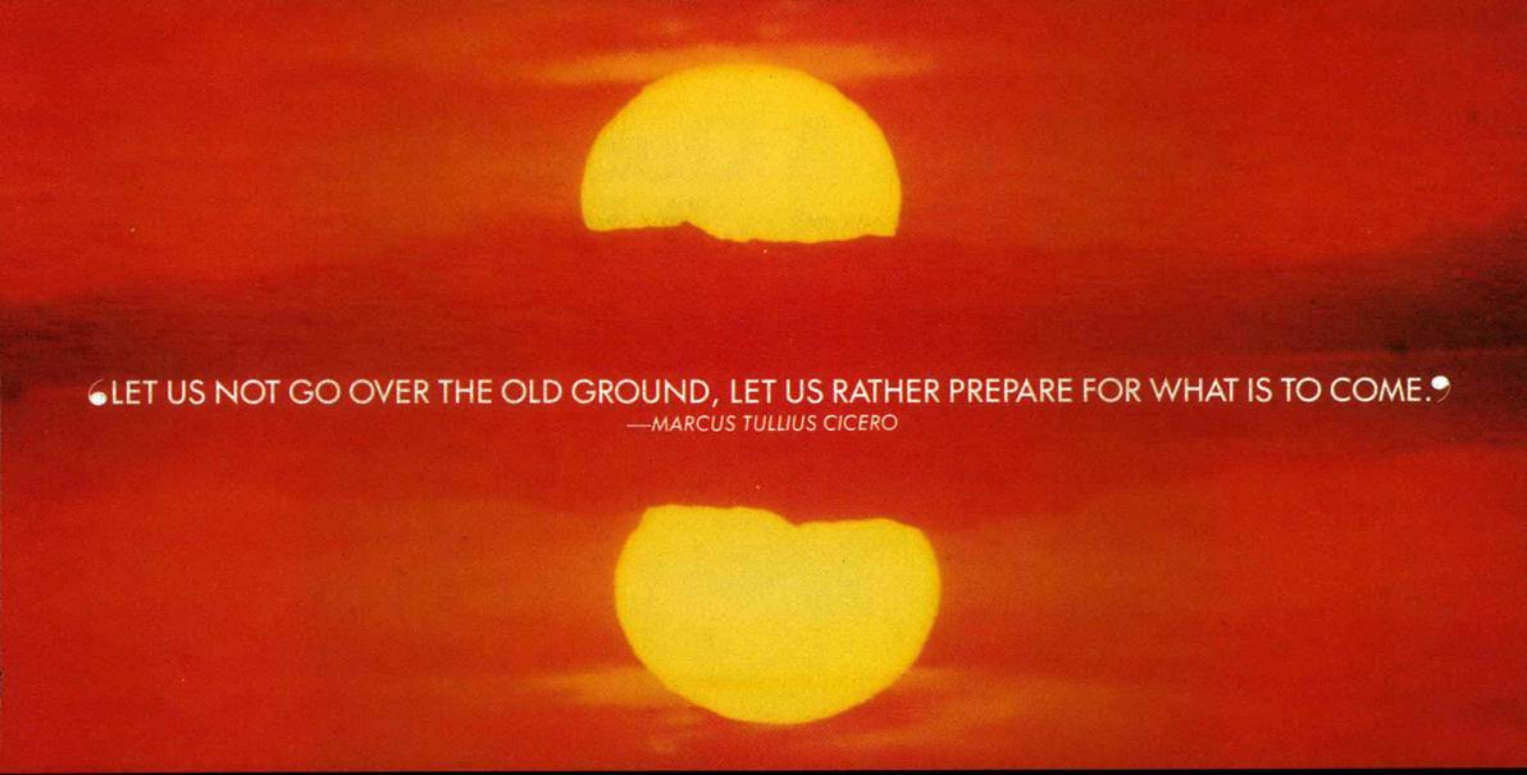
But he notes exceptions. "One scientist made a very detailed radio map of the Andromeda Nebula, and came back to show us the pictures that had resulted. Now, there was a special reason for his enthusiasm. During the Andromeda observations, just about everything that could go wrong did go wrong. Things sometimes looked so bad that the profusion of weird mishaps was jokingly attributed to Dutch TV, which was then showing the SF classic *The Andromeda Strain*."

As a Dutchman who remembers World War II very well, I looked along the array of dishes with special feelings. In 1944, when van der Hulst predicted the 21-cm line, liberation seemed tantalizingly near, but tens of thousands of Dutch would never see it. That last winter of the war would go down into history as the "Hunger Winter," filled with the horrors of starvation, ballistic missiles and, above all else, arrest and deportation. One name that kept turning up among the rumors was that of a concentration camp: Westerbork.



That camp was razed to the ground after the war. A simple monument commemorates the fragility of man's body, destroyed by narrow-minded fanatics and perverted pseudo-science. So it is on the site of that camp, that these dishes now look toward the universe, a symbol of a science that is pure, a science that never harms mankind, and constantly broadens his views and understanding. A fitting monument too, let us hope.

Frithjof Sterrenburg
Sijbekarspel, Netherlands



“LET US NOT GO OVER THE OLD GROUND, LET US RATHER PREPARE FOR WHAT IS TO COME.”

—MARCUS TULLIUS CICERO

OMNI MAGAZINE

BRINGS YOU CLOSE-UPS OF THE FUTURE AT A SPECIAL, MONEY-SAVING SUBSCRIPTION PRICE.

What's ahead in the 1980's? The '90's? The year 2000?

What scientific breakthroughs are happening now, or anticipated, in medicine? Space travel? Solar energy? Electronics?

You can be sure of this: The future will be different, fast-changing, and full of opportunities for those who plan for it.

OMNI is the magazine of the future. It is the leading publication and pioneer in reporting the new frontiers of science. Every month, there are new explorations to take. Voyages to the far reaches of the solar system and beyond. Journeys through the intricate universe of the human mind. Grand tours of the latest findings in oceanography, geology, chemistry, physics and much more.

OMNI also reports on new happenings in medical research. Looks soberly at UFO reports. Interviews our greatest scientists and philosophers. Entertains with the finest in science fiction.

Award-winning writing, breathtaking pictorials. In OMNI, you'll find quality and imagination. We publish and interview such creative giants as James Michener, Jonas Salk, Ray Bradbury, Isaac Asimov, Buckminster Fuller, Arthur C. Clarke. And each issue features some of the most spectacular art and photography found in any publication. It's the magazine for people who want to know more about now and what is to come. You'll get your money's worth many times over in information and entertainment.

Subscribe now for a 20% savings. A one-year's subscription to OMNI is only $23.95. That's 20% off the cover price! Just fill out and mail the coupon or postage-paid order card right away. With OMNI, you'll be ready for both today and tomorrow!

OMNI
THE ORIGINAL

OMNI
WHAT DO RICHARD PRYOR, SENATOR PROXMIRE, ARTHUR CLARKE, PIERRE TRUDEAU, MILES DAVIS, DUDLEY MOORE, POPE JOHN PAUL, AND MISS PIGGY HAVE IN COMMON?
THE ROBOT PROLETARIAT
MYSTERIOUS POWDER FIGHTS CANCER, DIABETES, AGING, OBESITY
FIRST PHOTOS OF THE MIND
SOBER-UP PILL

OMNI P. O. BOX 5700 BERGENFIELD, N.J. 07621 MFMA7

YES. Please send me OMNI for one year (12 issues) at $23.95.

☐ Payment enclosed ☐ Bill Me ☐ MasterCard ☐ VISA

Acct. # ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ Expire date: ____________

Interbank # for MasterCard ☐☐☐☐ Signature: ____________

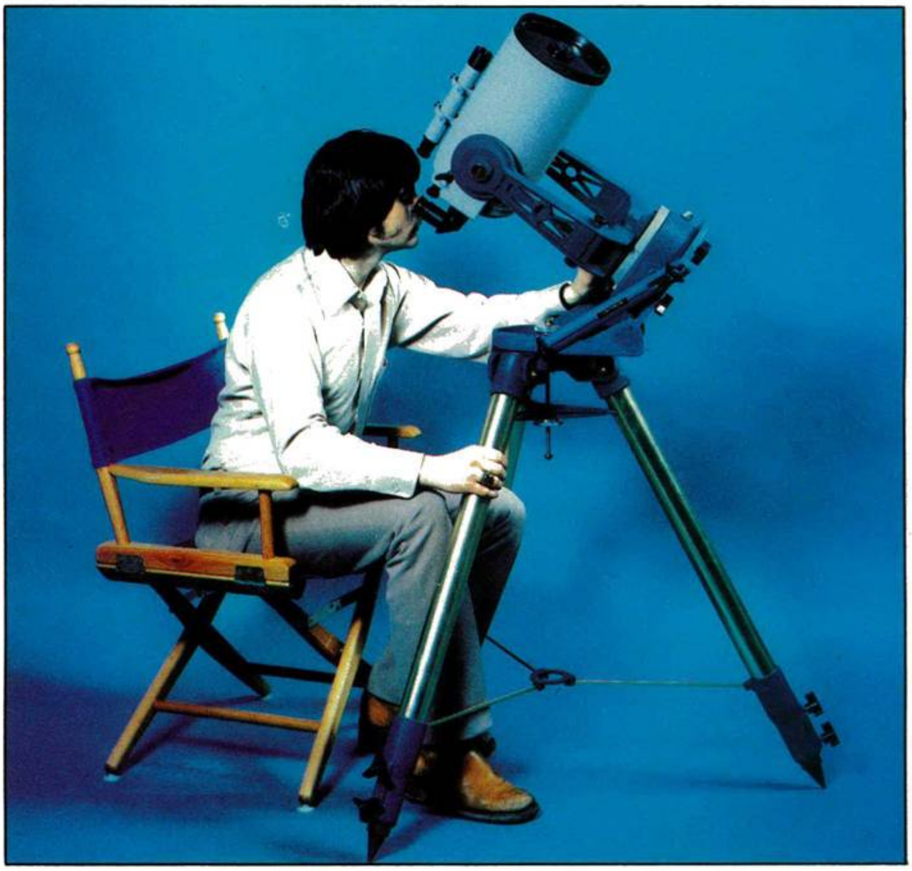
Name ____________

Address ____________

City & State ____________ Zip ____________

Please print. Rates for U.S. addresses only. Canada and elsewhere: $34, one year. Payment must be made in U.S. currency. Allow 6 to 8 weeks for delivery of first issue.

We Took A Good Thing And Made It Better.



World's smallest six-inch telescope, the DYNAMAX 6, mounted on CSi Golden Pyramid Field Tripod.

When we first looked into the Schmidt-Cassegrain telescope, we saw it was a good thing.

We saw incredibly sharp images...compact portability...an unbelievable potential for versatility.

We saw a professional-quality telescope you don't have to be a professional to operate.

And we decided to build it.

We looked at our design from every conceivable angle, optically and mechanically.

We refused to compromise. We refused to cut corners. We made the telescope as good as we could make it.

Then we improved it.

And improved it again.

Today, the DYNAMAX Schmidt-Cassegrain represents the latest generation of large-aperture telescope performance.

And it's the best value in a modern telescope in the world today.

Not just because we introduced a Schmidt-Cassegrain.

But because we made it better.

FREE COLOR CATALOG—When it comes to telescope performance, we wrote the book. And we'd like you to have a copy. Free. Write or call us today for your copy of the DYNAMAX color catalog and complete price list.

DYNAMAX®

Another precision optical product from

CSi

Where Vision is a Way of Life

CRITERION SCIENTIFIC
INSTRUMENTS

Dept. ASC-22 • 620 Oakwood Avenue • West Hartford, CT 06110
Telephone (203) 247-1696

In New York:
Robert T. Little
Field Sales Manager
212-834-1888

TeleVue™

...Even better than you imagined!

TELE VUE has developed new eyepieces that dramatically improve telescope performance. "Sharpest I've ever used" said Astronomy magazine's reviewer of our new Plössl designs. We now have these 50° field Plössls from 7.4mm to a giant 55mm 2" model that turns Celestrons into super wide angle scopes. A matched design 2.5x parfocal Barlow adds more flexibility, too.

Our patented 7-element 82° field Nagler eyepieces are the widest and sharpest yet developed. They're a sensation with Dobsonian fans. Adds a spacewalk quality to deep sky observing.

NEW 32mm Plössl

A GREAT GIFT IDEA!

Finest low-power eyepiece ever made. Full 50° field. Multi-coated, parfocal. Chromed brass 1¼" barrel.

$70 ppd.

We guarantee you will be absolutely delighted!

82° NAGLER EYEPIECES 7-Elements
MPT 5" f/4 True Refractor with 4-Element Objective
4-ELEMENT PLÖSSL EYEPIECES

TeleVue™
OPTICS, INC.
15-A Green Hill Lane
Spring Valley, NY 10977
Tel.: 914-354-4262

N.Y.'s ONLY COMPLETE TELESCOPE SHOWROOM

We know it takes more than fine equipment to enjoy the skies. *We're willing to get involved!* Let us help you understand polar alignment, explain celestial coordinates; show you how to use a star atlas; introduce you to astrophotography and put you in touch with local astronomy clubs. We specialize in the *guidance* of amateur astronomers.

Stocking dealer for:

• Celestron • Meade • Tele-Vue • Fujinon • Zeiss • Nikon • Pentax • Unitron • Lumicon • Optical Craftsman • Day-Star • Image Intensifiers • Books & Atlases

We are the exclusive New York representatives for the incomparable **QUESTAR** line of telescopes, night-vision devices and surveillance instruments.

Largest binocular display in the United States!

SANTINI OPTICIANS
2878 Merrick Rd., Bellmore, NY 11710
Closed Tuesdays Phone (516) 781-9846

ASTRONOMY's

Starry Sky Poster

The Starry Sky poster blends the beauty of the heavens with the history of astronomy.

The full-year version of ASTRONOMY's monthly Star Dome, the Starry Sky poster shows the entire northern sky at once — 6500 stars, plus galaxies, planetary nebulae, Messier objects, and the bright path of the Milky Way. Constellations are outlined for easy identification.

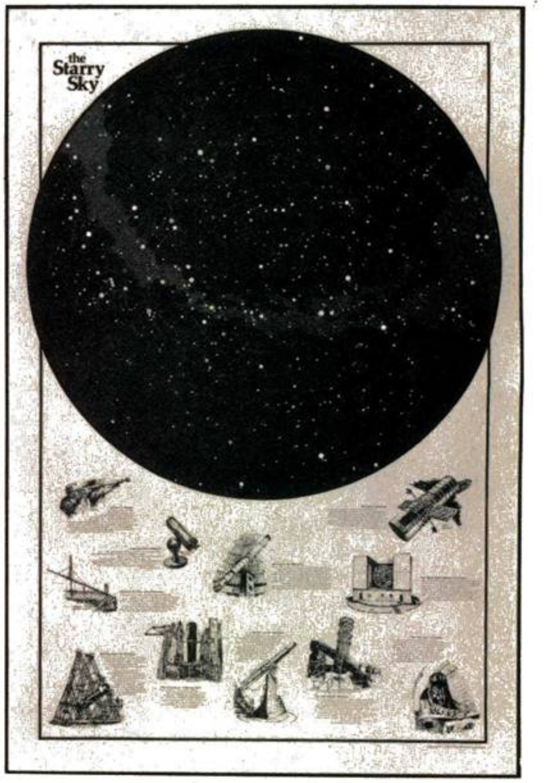
Below this starry expanse is a capsule history of the telescopes that have guided astronomy from the 1600s to the future. Galileo's one-inch window on the solar system, Hevelius's long refractors, the Hale 200-inch — all the way to the MMT and the Space Telescope. Eleven telescopes in all — each one illustrated and accompanied by a brief history of its accomplishments.

Beginning star gazers, veteran astronomers, and everyone interested in the history of astronomical thought will enjoy this attractive poster.

FULL COLOR — 24" x 36"

$6.95

postage and handling included



To order, use the AstroMedia order form bound into this magazine or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202

ASTRONOMY
IN FOCUS

Texas Star Party

Sir / You might have to be plumb crazy to haul your telescope across hundreds of miles of oilfields and roadrunners to chance an unknown, untried astronomy/ATM meeting hosted in the middle of nowhere. But we Texans don't think much of distance, and neither did the 440 crazy amateurs who came from 29 states to attend the Texas Star Party.

The point of this letter is to settle all that hootin' 'n' hollerin' over the fact that the Star Party coincided with another conference, Riverside, nearly a thousand miles to the west.

Now we're every bit as sorry as an armadillo under a steel-belted radial about the conflict, but all this jaw-bonin' wasn't an issue at all at Fort Davis, where most of us were southern and mid-American amateurs mighty grateful to have a major meeting a lot closer to us than any available in the past. But in hope of clearin' the air a bit I'll set the record straight . . . .

In a nutshell, the Texas Star Party took place where it did 'cause the Prude Ranch is just about the only source of shelter and electricity west of the Pecos. And the Star Party took place when it did 'cause that's when Rancher Prude said we could have it! Besides, nobody would want to be there in the middle of 700 screaming kids during Prude Ranch Summer Camp, and they wouldn't be there in late summer when the Davis Mountains get most of their annual 16 inches of rain. September to late May is when the kids are in school, and we weren't about to let these most enthusiastic of all amateurs down.

But most of all, the Texas Star Party is the chance of a lifetime for us to see what dark skies are all about, and we caught a lot of fire for hosting it as far from the New Moon as we did — 3 to 7 days old. Besides, the chance for observing time on the 82-inch Struve Reflector at McDonald Observatory at the end of May was too good to pass up.

So in the future, the Texas Star Party will likely continue to take place sometime in late May or early June, near New Moon, as requested by those southern and mid-American amateurs who attended our 1982 meeting and plan to keep comin' back. Now I know we're gonna open up a whole new can o' worms with somebody every time we decide to do this, but our meeting is the first real opportunity for these folks down here to enjoy what they've been missing up to now — so they're the ones we'll think about when scheduling time comes around in '83, '84 and beyond.

As for everyone else who wants to enjoy some good ol'-fashioned astronomy under the darkest skies you've ever laid eyes on, just come on out and observe with us, 'cause the gazin's great in the Lone Star State!

George D. Ellis
Texas Star Party Coordinator
Fort Worth, TX

Fields of View

Sir / Some of the values in the field-of-view table accompanying "How Much Sky Can My Camera Capture?" (June 1982) aren't quite right. The reason is that the formula given in the article:

$$A = 57.3 \times (W/F)$$

where W is the width or length of the picture area on the film, F is the focal length, and A is the angle of view in degrees, is only an approximation to the correct formula:

$$A = 2 \arctan (W/2F)$$

The two give noticeably different answers when A is greater than about 20°. Using this formula, the first few lines of the table should read as follows:

focal length	24mm dimension	36mm dimension
18mm	67°	90°
28mm	46°	65°
35mm	38°	54°
50mm	27°	40°

The rest of the table is accurate — when the focal length is greater than about 80mm, the error introduced by using the simplified formula is generally negligible.

Michael Covington
Athens, GA

Science Illiterati

Sir / I enjoyed Gary Mechler's "The Science Illiterates" in the August 1982 issue.

It is disturbing to see creationists given assistance from our highest office. I'm sure that if Jerry Falwell had his way we'd be attending Sunday night prayer meetings instead of being out under the original.

Right now we seem to be ahead with the Arkansas decision. But don't count out the creationists yet. We still may be carrying the little black book on Sunday nights instead of the 6-inch reflector.

Jay Bryant
Eureka, CA

Reviving an Old Refractor

Sir / Thank you for Ernest Underhay's "Rethinking Your 60mm Refractor" in the June ASTRONOMY. It struck a responsive chord with me.

After I spent months plaguing the family with my new-found interest in astronomy, my father purchased a 2.4-inch for me for Christmas in 1964. The scope came with an altazimuth mount, a 5x30 finder, two eyepieces, a book, and chromatic aberration. I was dismayed at first when my views of Mars and Jupiter weren't as good as the pictures in books, but after I got over the initial disappointment, I used my scope at every opportunity.

Unfortunately, that 2.4-inch was the last Christmas present my father ever gave me — he passed away a month later — so the scope has become a cherished keepsake for me. I have kept it ever since, although I retired it in 1966 when I contracted aperture fever.

Around then, the prevailing attitude among my amateur astronomer friends was that nothing short of a 6-inch was any good for observing unless it was a catadioptric — so I ground my own mirror and soon assembled a respectable 6-inch. I have used it to good advantage through the years, but I must admit it gets tiresome lugging it out to observing sites and then lugging it back.

Because of Mr. Underhay's article, I have decided to revive my old scope, clean off the dust, modify it to accept 1¼" eyepieces, and put it back into use. It will be a challenge to refute the old idea that it is "next to useless" as an astronomical instrument, but I have a feeling that I will be surprised at the wonders it reveals in the night sky.

Sandra Mesics
Bensalem, PA

Metric or "American"

Sir / The use of metrics in your magazine leaves me cliff-hanging. By the time I strain my memory banks and try to convert into American, the effort has cost me dearly.

I was delighted to see some American slip into an article recently — no blue pencil? Distance was actually referred to in miles.

How about a poll of your subscribers letting them express their wish for American or metric? Or simply include both?

C.M. Johnson
Lakeside, CA

— ASTRONOMY uses both the metric and English (please, it's not American) units — depending on which is most appropriate. For articles primarily about astronomical bodies, we generally use metric units. If English units can significantly aid our readers' understanding of a story, we use English units. For articles on equipment or observing, where a reader probably buys and uses it in an English unit context, we employ the English system, except when — as is the case with eyepiece focal lengths — metric units are more common.

Meanwhile, don't strain your memory banks — when talking about astronomically large distances, a billion kilometers and a billion miles are about the same. All the human imagination can make of a "billion" is "BIG" — whatever the units — but kilometers aid subsequent calculations and comparisons more than miles.

Printing different units side by side, we feel, is confusing. All scientists and most of humanity use the metric system (including Americans — all electrical units here, for example, are metric), so you might as well learn your off-planet measurements in kilometers and grams/cm^3. Save the English system for earthly uses.

Ooops!

Sitting in the hot Florida sun too long must bake your brain, judging by the mistakes that appeared in our August Shuttle article!

To set the record straight, in proper NASA terminology, the Shuttle is rolled out to the launch pad on the Mobile Launcher Platform and serviced there by the Fixed and Rotating Service Structures (FSS and RSS). The cover shows the RSS rolled back two nights before launch. At launch, the Shuttle Main Engines, burning with a nearly colorless flame, ignite 6.8 seconds before liftoff.

Also, our apologies to Robert Gewin whose photo of Auriga on page 46 of the September issue was mistakenly credited to Stephen Walther.

behind the scenes | a summer of amateur meetings

This year I've attended more astronomical meetings and conventions than ever before, and enjoyed meeting many people and talking about astronomy. Meetings are fun — and you learn an awful lot.

So, just to give the flavor of one such event, I've written about the Astronomical League national convention in this month's Forum; and next month we'll be running an update and report on amateur telescope making in Equipment Atlas.

If you want to know where and when meetings occur, just check our AstroCalendar — it provides the date, place, and people to contact for more information. AstroCalendar is a relatively new feature on the last page of AstroNews.

One of the reasons I've attended so many meetings this summer is that readers have asked for greater coverage of amateur astronomy. I talked to lots of people about what they'd like to see — and I'd like to ask you, too. If you have strong feelings about increased coverage of amateur events, please drop me a line.

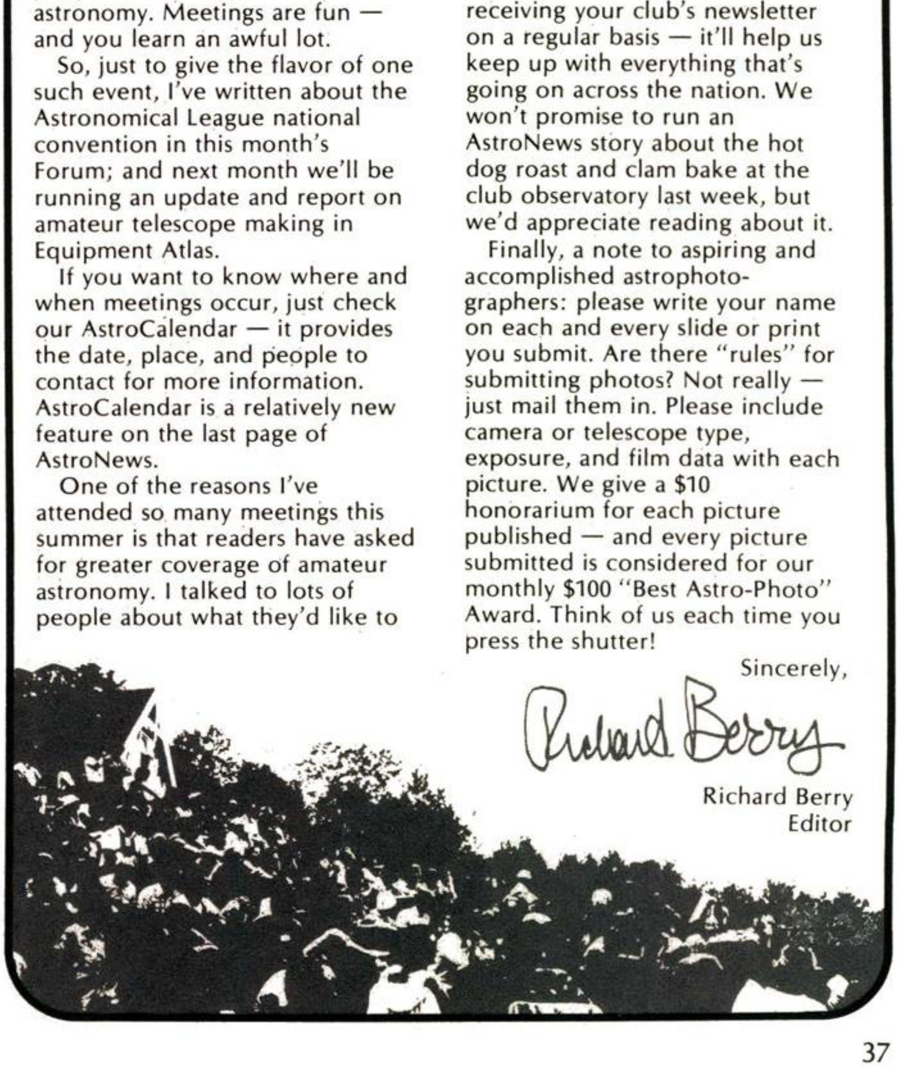
Meanwhile, we'd appreciate receiving your club's newsletter on a regular basis — it'll help us keep up with everything that's going on across the nation. We won't promise to run an AstroNews story about the hot dog roast and clam bake at the club observatory last week, but we'd appreciate reading about it.

Finally, a note to aspiring and accomplished astrophotographers: please write your name on each and every slide or print you submit. Are there "rules" for submitting photos? Not really — just mail them in. Please include camera or telescope type, exposure, and film data with each picture. We give a $10 honorarium for each picture published — and every picture submitted is considered for our monthly $100 "Best Astro-Photo" Award. Think of us each time you press the shutter!

Sincerely,

Richard Berry

Richard Berry
Editor



SOME REASONS WHY YOU SHOULD MAKE US YOUR FAVORITE CELESTRON TELESCOPE DEALER

- We think our customers are just as honest as we are so we accept personal checks and ship scopes immediately from our large stock without waiting for the checks to clear. Our friends think we are crazy but we feel that a reputable mail order business should be based on trust. You trust us so why should we not trust you? We give you personal service both before and after you order.
- We resist selling you what you ask for if we feel it is not appropriate for your current skills. We specialize in helping beginners choose the correct equipment and accessories.
- You do not have to purchase anything to get the benefit of our 20 years of amateur experience and valued judgement on things astronomical.
- We know the Celestron line almost as well as the manufacturer since we have units in daily personal use.
- We know the strong and weak points of all commercial scopes. Maybe some scope other than a Celestron is best for you — if so, we will tell you.
- We have developed a line of unique Custom Engineered accessories for Celestron telescopes so they will operate with less hassle when fitted with them. NO GIMMICKS — all made to help the beginner.
- **DON'T BE AFRAID** — Our Mail Order shipments to any place in the world are shipped in special scope containers. If by remote chance the scope arrives damaged we ship you a new one and WE handle the claim with the shipper — YOU don't. **WE EXPORT SCOPES WITH ANY VOLTAGE AND FREQUENCY FOR EITHER HEMISPHERE** AND SHIP C-8's to EUROPE **FREE.**
- Do you feel the need of an astronomical friend? Call me. I would be glad to help you. I love astronomy and wish everyone did.

Roger W Tuthill

- **PRECISION POLAR AXIS FINDER** (USA Patent #4,260,253). Get perfect celestial polar alignment quickly and easily every time without leveling your tripod. When the centered 4X crosshairs are set on Polaris the built-in 0.8 degree offset barrel points directly and precisely to the pole. Novel Polaris date and time chart supplied FREE. Now available with FREE Ring-o-Fire Glowing crosshairs for easy viewing.
- **NEW IMPROVED GIANT FINDERS.** 50mm or 80mm Right Angle or straight thru. Easy mounting to all scopes. Fingertip collimation adjustment. Now equipped with our Ring-o-Fire glowing crosshairs for easy viewing. No wires or batteries.
- **NEW IMPROVED ISOSTATIC EQUATORIAL MOUNTS** (See above). For Celestron 90, 5,8,or 11 as well as Meade #2080 or Dynamax 8. Stops vibrating in 1/2 the time of any adjustable tripod and wedge combination on the market. Sturdy, light weight, adjustable-height aluminum legs.
- **CLAVE AND TELEVUE PLOSSL EYEPIECES** — ALL SIZES.
- **WE DO NOT SELL EITHER MEADE OR DYNAMAX SCOPES BUT WE MAKE SOME NIFTY ACCESSORIES THAT ENHANCE THEIR USEFULNESS.**
- **LARGE BINOCULARS, NO DU CAPS, LUNA SHADE MOON FILTERS, CAMERA DRIVES, & ILLUMINATED RETICLES.** We sell EDMUND SCOPES TOO. We also sell STAR-TRAP DRIVE CORRECTOR AND ELECTRONIC EYEBALLS

WE FINANCE SCOPES LOOK NOW PAY LATER

CELESTIAL NAVIGATOR

THE MISSING LINK ANOTHER TUTHILL TRIUMPH

HIGH ACCURACY/LOW COST DIGITAL CIRCLES

The CELESTIAL NAVIGATOR MARK III consists of separate, independent, self-contained R.A. and Dec. units with built-in batteries good for any country in either hemisphere. SEND FOR USER REPORT.

THE STEREOOCULAR®

A binocular viewing device. Great for spectacular views of the Moon, Sun, Planets, bright nebula and terrestrial objects.

Gives a 3-dimensional effect with brighter views than other units since it takes 1¼" eyepieces and give upright images with large prisms and NO barlow.

Two people can view at one time. For use on compound scopes and refractors. Write for user report.

Recognized As Headquarters For Telescope Solar Filters Solar-Skreen® Sun Filter

SOLAR SKREEN Sun filters (USA Patent #3,897,140) fit all scopes and use no glue or magnets. Double aluminum surfaces are shielded from damage. The fine qualities and SAFETY of this filter are described in detail by Dr. B.R. Chou in *Sky and Tel.* pg. 119, August 1981, and *Astronomy* Review, March 1981, pg. 75.

Send a LARGE 8½" x 11") BROWN Self-Addresed Stamped Envelope (2 oz.) if you want complete info including our new FREE catalog which illustrates all our unique aids to your great hobby.

MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL

Interested in a Schmidt Cass scope? We urge you to get a Celestron EVEN if you don't get it from us. You will be a lot happier with the optical perfection and proven performance.

WE REPAIR CELESTRON SCOPES

Master Charge, VISA *Trade Mark

ROGER W. TUTHILL, INC.

Telephone: 201-232-1786 (N.Y.) 212-926-6498 (L.I.) 516-794-2050
11 Tanglewood Lane, Box 1086A, Mountainside, N.J. 07092

seeing double

by Ken Hulme

T.W. Webb, William Olcott, and Newton Mayall trusted them. Nineteenth century clipper ship captains wouldn't venture onto the high seas without them. Birdwatchers and sports fans relish their crisp, sharp views. But sadly, many backyard astronomers think binoculars are too small to be useful. Binoculars, which bridge the gap between naked-eye and telescopic observation, offer low powers and wide fields. And they are now enjoying a revival of popularity as an inexpensive but powerful optical aid.

For simplicity and portability, take along a pair of binoculars on your next evening of stargazing. Even those who use large telescopes will thrill once again at the stunning vistas the simple field glass opens up. Many backyard astronomers get caught up in a "bigger is better" syndrome, and forget the beauty and convenience of low-power observation once they buy a telescope.

Next to your naked eye, binoculars are the least expensive piece of equipment to help you stargaze. They also serve as an appropriate step up in equipment to aid your astronomical education. After many evenings of naked-eye viewing, you'll become familiar with the constellations and movements of the celestial sphere. Soon you'll want to add a little more power to your observing arsenal and tackle fainter objects.

Instead of immediately investing in an expensive telescope, consider binoculars as a possible alternative to the quest for more magnification and light-gathering power. Many classical observers felt a novice should graduate to binoculars only after becoming familiar with the naked-eye appearance of the heavens. The purchase of a telescope was deferred until later. Many observers still ignore this wise advice, and impatiently jump headlong into a telescope purchase only to find out that telescopes are usually heavy, expensive, and complicated to use.

binocular numbers

Type	Power	Aperture (mm & inches)
6x15	6	15mm - .6"
6x30	6	30mm - 1.2"
7x35	7	35mm - 1.4"
7x50	7	50mm - 2"
10x50	10	50mm - 2"
15x60	15	60mm - 2.4"
10x70	10	70mm - 2.7"
11x80	11	80mm - 3.1"
20x80	20	80mm - 3.1"
20x120	20	120mm - 4.7"

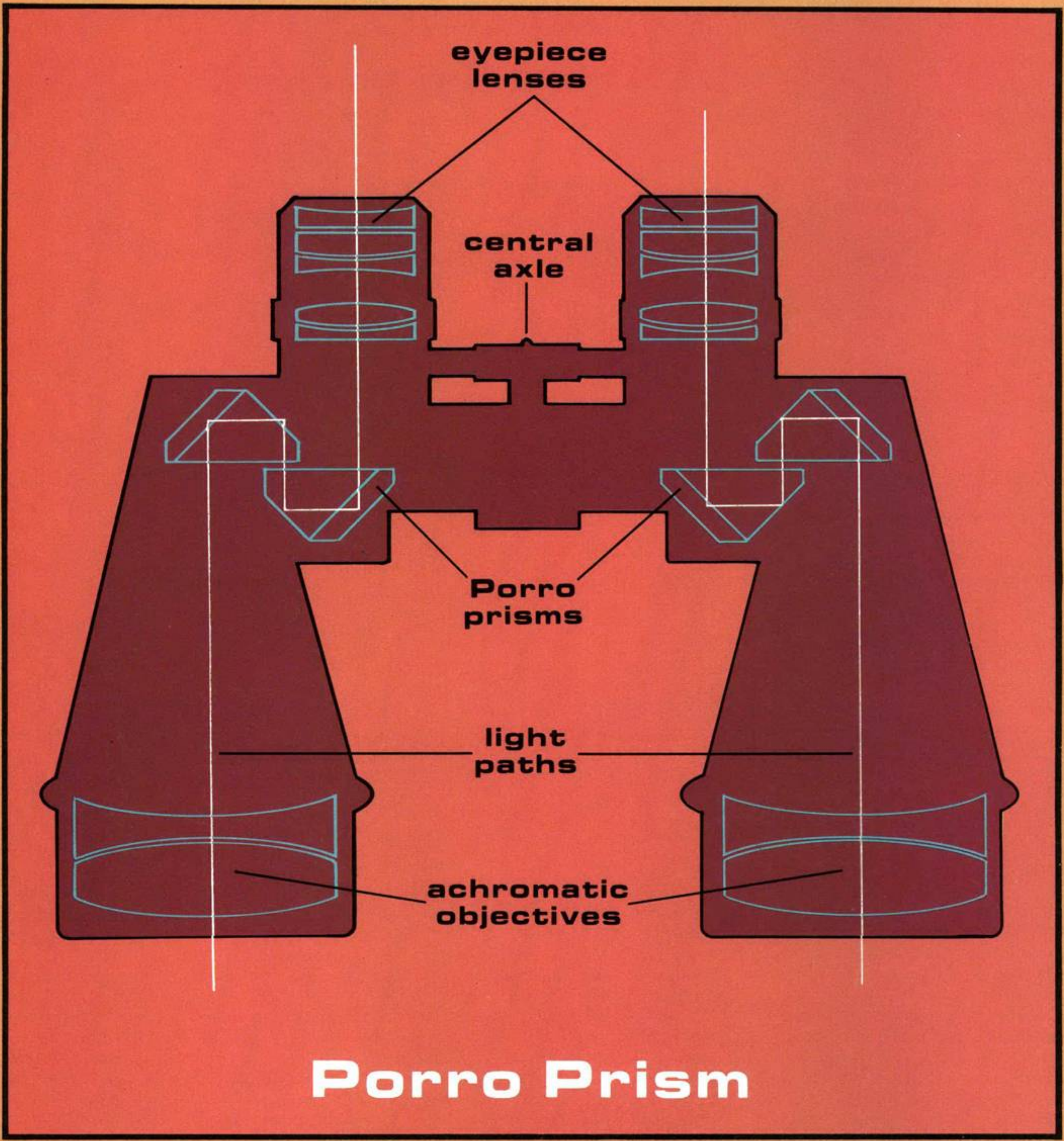
Just what are binoculars, and how can they help an observer? In simple terms, binoculars are two identical, independent optical systems that are precisely aligned — like a small telescope for each eye. Your brain processes the two incoming images and assimilates them into one picture that has an illusion of depth.

The objective-lenses and eyepieces are matched achromats, and in the optical path between objective and eyepiece you'll find a prism that erects the image and presents it in a correct left-to-right orientation for terrestrial viewing. These dual scopes are connected by an axle that allows you to change the parallel positioning of the optical paths to accommodate the varying distance between different observers' eyes — called the *interpupillary distance*. Also connected to this axle in some models is the focus mechanism — either a knurled ring or a flat plate. Newer designs incorporate an "instant-focus" feature. Most manufacturers also offer an additional individual focus, called the *diopter* focus, on the barrel of the left eyepiece to help those observers who have unmatching eyesight.

The optical systems of binoculars, like those of refractor telescopes, are sealed to maintain precise alignment and to keep out dust and dirt. As long as you store them in their case with their lenscaps on and occasionally clean the outer lens surfaces with lens cleaning fluid and a lint-free tissue, most binoculars will last for a lifetime of trouble-free operation *without* additional care. If they do require service, it's best to return them to the manufacturer for repair.

Binoculars have two main types — roof prism and Porro prism. The type of prism affects the size and weight of the instrument. Porro prism binoculars are most familiar to observers — they have the classic binocular shape, and are sometimes big and bulky. The newer roof prism varieties have a more direct light path, with considerable savings in size and weight. Their compactness and lightness make them popular with many observers.

Field glasses differ from true binoculars because they have negative



Porro Prism

focal-length eyepiece lenses that deliver an upright image — but only of very low power. They also lack the prisms that true binoculars use to shorten their overall length. Field glasses were popular in the 19th century, but improved technology has led to more compact shapes. Both field glasses and binoculars use optically matched lenses to bring the focused subject to your eyes, and you can find both types with individual eyepiece focusing or coupled focusing. The price increases for each as the magnification and objective diameter increase.

You can purchase binoculars for as little as $20, provided you search flea markets, pawn shops or garage sales.

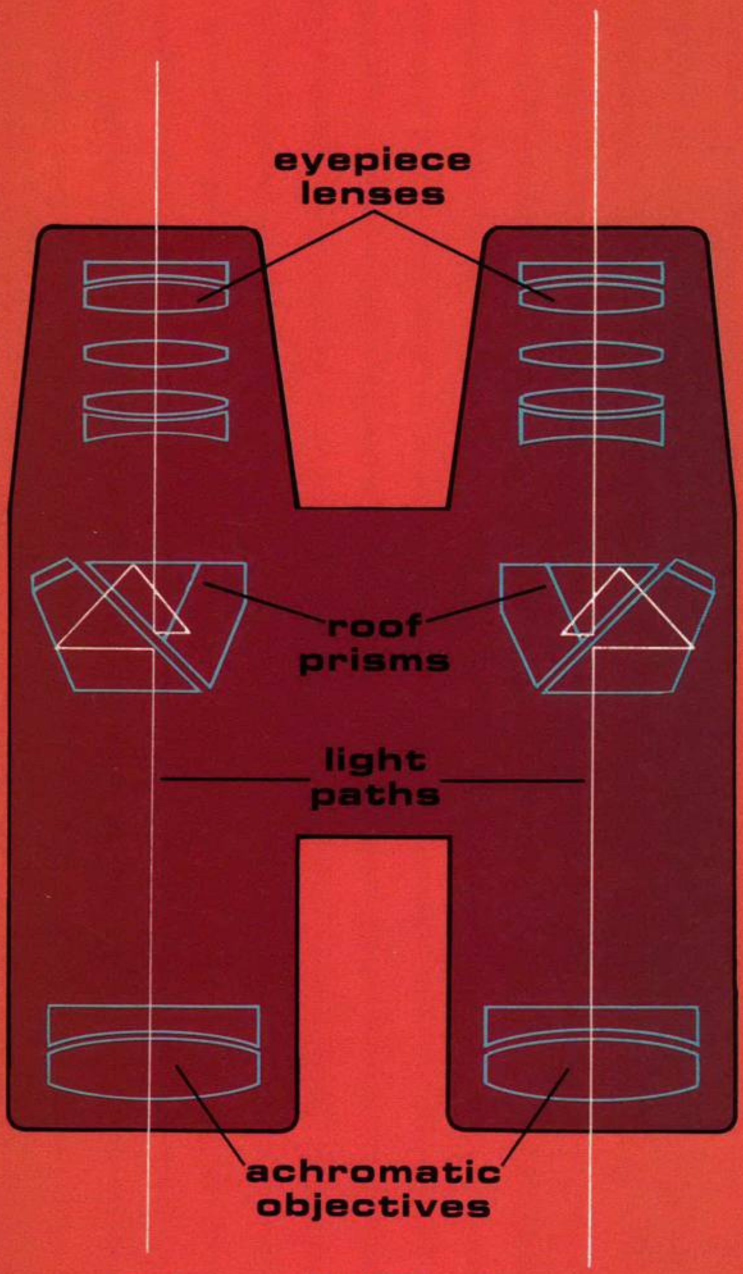
Buying a pair of binoculars is probably the single most useful astronomical purchase you can make. Observers reap several benefits when using binoculars: First, since you use both eyes for viewing, you don't develop eyestrain during long observing sessions. With reduced eyestrain, you spend more time stargazing.

Second, again since you view with both eyes, the image, whether it is of the Moon or of a faint nebula, has a three-dimensional appearance that enhances the psychological feeling of actually "seeing" the object.

Finally, locating objects is so easy — just aim and scan — that your knowledge of the night sky will improve through use.

Binoculars are the next step up from naked-eye observation, and give narrower fields of view, increased sky/star contrast, and of course improved light grasp. In addition to astronomical uses, plenty of daytime sights will command your attention if a pair of binoculars lie close at hand.

Like telescopes, binoculars come in a bewildering variety of styles, types, and sizes. The first thing to consider is the number classification, such as 7 x



Roof Prism

35 or 10 x 50. These numbers indicate the magnification and the objective diameter. A 10 x 50 binocular has 10 power magnification and two 50mm objective lenses. Like telescopes and cameras, the objective diameter determines the light-gathering power of the optical system. Telescopes and cameras indicate the light grasp by an f/rating. Binoculars use the term *relative brightness*.

With any optical system you have a trade-off between magnification and image brightness, and binoculars are no exception. With more magnification, you have less image brightness.

Another important binocular characteristic to consider is the field of view, expressed in feet of width at a set distance — usually 1000 yards. Some simple trigonometry will help you convert this figure to an angular field of view. For example, let's say a given binocular has a listed field of view of 390′ at 1000 yards.

Relative Brightness =

$$\frac{\textbf{Objective Diameter}^2}{\textbf{Magnification}^2}$$

Thus, a 7 x 35 binocular has a relative brightness of $35^2 / 7^2 = 25$.

Binocular	**Relative Brightness**
7 x 35	25
7 x 50	51
8 x 30	14
8 x 40	25
10 x 50	25
11 x 80	53
20 x 60	9

It will help to think of the field of view as composed of two right triangles. Divide the field of view by 2; then divide that number by the range distance (expressed in the same units). Use a calculator with trig functions, or look for your answer in the tangent column of a trig table and find the corresponding degrees and minutes of

binocular buying tips

You can probably find many stores in your area that sell binoculars, so you won't have to rely on the impersonal service of mail-order buying. First, consult the Yellow Pages listing under "Binoculars." You'll find that many different types of retail outlets include binoculars in their inventory. Camera stores, gun shops, optical centers, and even telescope stores may carry binoculars as a supplement to their other goods. Of course, most large department store chains will have them in their camera or sporting-goods sections.

Having "hands-on" experience before purchasing may help you avoid a costly mistake. After you've decided what type and size best fits your observing needs, approach the salesman and let him give you his sales pitch. Tell him right away you'll use binoculars mainly for stargazing. This may help him advise you on the merits of the particular brands he sells.

Take the pair he recommends and heft them in your hands to gauge their "feel." Remember that binoculars are hand-held optical aids, and their weight has a great deal to do with the amount of useful observing you can do. Check the focus mechanism to make sure it's smooth. Tell him you would like to take them outside — to avoid looking through a plate-glass window — so you can judge the optical quality. The image should be bright, crisp, and clear. Train the binoculars on distant objects and carefully note the appearance at the edge of the field. Is it as sharp as in the center? Next, aim them at a bright light (NOT the Sun!) and see what kind of spurious color results. If the chromatic aberration is too great, you'll see rings of color around the light — just like you'll see around any star or planet you might look at.

Finally, judge the mechanical quality. Although most modern binoculars are well-made, you may encounter some bargain brands that wobble around the central axle, or just don't feel as rugged as you'd like. If you notice any of these problems in an off-the-shelf pair, you can bet the problem will worsen through use.

As with any optical instrument, name brands are more expensive but usually worth it because of the company's warranty and reputation. In any case, insist on being able to return them if they don't perform well. (Make sure you keep them in mint condition — or they'll be yours for good.) Most stores will let you return merchandise that is in saleable condition — but check before you pay!

angle. This is half the angle of the field of view.

From the example above: 390/2 = 195, 195/3000 = .065; .065 = tan 3°44', field of view equals 7°28'.

Ordinary binoculars have fields of view between 5 and 8 degrees. Wide-angle binoculars will have fields of view between 8 and 10 degrees, and extra-wide-angle binoculars may have 11 degree fields or more.

Big binoculars with magnifications of 20x or greater, and objective diameters between 80mm and 120mm, are instruments for experienced observers and because of their weight and magnification are hard to use without a mount. You should consider their purchase as seriously as that of a telescope. Most 20x binoculars fall into the $200+ price class. Big binoculars are nice, but all binoculars are helpful since they provide increased light grasp and a magnified view.

Several factors are important regardless of the size you need. First, the best optics deliver the highest resolution and least eyestrain. Most binoculars today come with coated lenses to reduce reflections and improve image contrast, but the coating must be applied to all lens surfaces for the best results. Another important consideration is the size of the exit pupil — the bright disk of light emitted by the eyepiece.

To calculate the exit pupil diameter, divide the binocular's objective lens diameter by its magnification. For example, a 7 x 35 binocular produces a 5mm exit pupil. For normal daytime use, a 3.75mm or larger exit pupil is sufficient. But for stargazing, you'll want an exit pupil approaching 7mm, the maximum size of the fully dilated human pupil. A pair of 7 x 50 binoculars will deliver this.

For general observation, the 7x, 8x, and 10x models are ideal. Get the 50mm objective size if you can afford it — especially the 10 power models. No matter what size you can afford, they will add to your observing pleasure.

Almost all regions of the sky make interesting binocular targets. For starters try any of these:

Sagittarius, Scorpius, Scutum, the Cygnus to Cassiopeia area, or the Summer Triangle. The Andromeda Galaxy (M-31), the Orion Nebula (M-42), the Double Cluster in Perseus, the Pleiades, and the Beehive are other fine objects. (See "21 Objects for Binocular Observers," page 82.)

Remember, you're supposed to enjoy your time spent observing. If you're craning your neck for several hours, how can you expect it not to be sore? You'll find the weight of your binoculars has an important bearing on the amount of time you use them. If they're too heavy to hold, make some sort of observing stand. At the very least you should lie down, either on a blanket or a lawn chair, or try to rest your elbows on a solid surface so your arms don't take the brunt of the weight. Holding a pair of binoculars for a long observing session will quickly convince you of the need for a stable platform. There's nothing worse than the unsteady image tired arms give: How much can you expect to see when your elusive object dances back and forth across the field?

Obviously you need some form of mechanical observing aid. An ordinary camera tripod is a good support for binoculars if the pair has a ¼-20 camera thread hole, or is adaptable to the tripod head in some manner. Most binocular manufacturers supply a camera-tripod adaptor for their models. Consult your dealer for the proper equipment.

Some observers have custom-designed chairs or other binocular observing aids, and their function is only limited by your own ingenuity. Some have combined alt-azimuth mounted binoculars with a lawn chair to ease the strain on hand and neck muscles. All you need is a pipe extending from the back rest to help hold the binoculars in place. A tabletop alt-azimuth stand can also make a good mount.

Just for the fun of it, the next time you plan to stargaze, leave your scope inside, dig up your old pair of binoculars, and spend a few leisure hours just looking around. And if you've never had a telescope and thought binoculars were too small to show anything, you'll be very surprised when you find out what you've been missing.

Ken Hulme is a technical writer for Engineering Measurements Corp., and a free-lance science writer.

ASTRONOMY
REVIEWS

Space Images
Robert Littman and Richard Mauerer
96 pages, paperback, $15.95
Lustrum Press (1982)

This is a beautiful book, an "art" book of photographs from space. "These images, from JPL/NASA," reads the miniscule introduction, "were first presented at an exhibition at the Grey Art Gallery and Study Center, New York University...." In the summer of 1981, when the exhibition went on, photographers who have fought to have photography accepted as "art" found themselves looking at images in an art gallery taken by machines, scientists, and astronauts. It must have been a shock for many.

The book contains 76 black and white duotones and 16 color images arranged in roughly solar system order beginning with the Moon. Many images are not the standard shots we've seen before, but were picked by the sensitive eye of Richard Mauerer, guest curator of the original exhibit. Mauerer appreciates the magic of photography from space as few scientists, primarily concerned with their data content, allow themselves to be. Lustrum has done a beautiful job — there is virtually no text — so the images can speak for themselves.

The book opens with Lunar Orbiter and early Apollo images, notably the strange double crater Pickering and striking views of a large crater, perhaps Tycho. Then a series of overlapping sequential images from a mapping camera, on pages 14 through 18, allows us to glide silently over the Moon, before subsequent unreally crisp photographs guide us to a landing on page 25.

The lunar surface pictures, pages 26 to 44, were the high point for me. Maybe they were jet jockeys, but given good cameras and plenty of film, even astronauts can take utterly enchanting pictures. Those I find myself most drawn to are on pages 30 and 39. In both, the lunar landscape dwarfs the machines from Earth, but in the one on page 30, the faint lunar buggy tracks and footprints made by the astronaut who took the picture transport me to the scene. Mauerer also seems to like pictures with human artifacts present.

The awe-inspiring desolation of the Moon — pages 27, 31, 36, and 44 — comes through sweeps of rocks, powdery surface, and rolling hills. The quality of the images is outstanding — the ultra-fine-grain films used seem to hold limitless detail. NASA's press release pictures, geared toward low-fidelity newsprint media, can't touch these reproductions in sharpness or tonal quality.

Curator Mauerer has also found a superb version of the hackneyed "astronaut reflected in another astronaut's visor" on page 41.

From the Moon, the book moves to Mariner 10 Mercury and Venus images, each presented complete with image data readouts beside or under the frame. For the art community, these artifacts must seem baffling and do certainly underscore the machine-made nature of the images, raising over and over that haunting question, "Can machines make art?"

Mars is represented by a few composite images, a sequence of exposures of Phobos, and one surface picture, then *Space Images* hops to Jupiter. Page 60 has a stunning image, very 3-dimensional, of Callisto above the jovian clouds that I hadn't seen before, but opposite, on page 61, a poorly reproduced image of Io in front of Jupiter detracts considerably. The spread on pages 70 and 71, a composite view of the jovian rings (not Saturn's as the book labels it) is a press release image. It is minimal — just a thin oval delineated in a series of tilted black rectangles — possibly included because it recalled abstract paintings to the curators.

All of the Saturn images are standard press release pictures that have run in ASTRONOMY, though those chosen tend to be simple, highly patterned, and abstract.

I was disappointed with the color section. One image of Saturn, page 81, has a moire pattern, and another of Jupiter, on page 82, suffers from severe posterizing in the black and cyan printers. The image of the Vallis Marineris on page 85 is new and quite pretty, but most of the color lacks the depth and contrast of the original prints. ASTRONOMY has reproduced most of them much better.

On the whole, however, this is a book very much worth having. While I'm aware that it raises artistic questions that must be profoundly disquieting to artists, photographers in particular, there is no escaping the beauty or impact of *Space Images*.
Richard Berry.

Life in the Universe
John Billingham, ed.
461 pages, hardbound, $20;
paperback, $12.50
MIT Press (1981)

When we envision the forms extraterrestrial life might take, we can choose two diverse paths. The first is inspired by science fiction and comic books, and leads us to bizarre speculations on strange beings with extraordinary powers. The second path is that of the scholarly study, grounded in careful research and *a priori* reasoning. *Life in the Universe*, a collection of papers given at "A Conference on Life in the Universe" held in 1979 at NASA's Ames Research Center, fits into the latter category.

The book's format has a certain logic and sense; it opens with the creation of the universe then turns to the physical and chemical processes of evolution on Earth, and the environmental necessities for life on Earth. It goes on to examine possible evolutionary patterns and concludes with methods of searching for extraterrestrial life.

The serious study of life outside the solar system is not the exclusive domain of space scientists or astronomers. Instead, researchers have melded an interdisciplinary approach which brings in the expertise of the life sciences as well. This synthesis has been termed exobiology — the study of life outside the Earth. Thus, the reader will encounter articles by paleontologists, geologists, chemists, and biologists in addition to the views of astronomers.

Scientists now think that extra-solar planets could be the rule rather than the exception, and that life has probably emerged and evolved not only on Earth, but elsewhere in the universe.

The standard arguments concern the statistical likelihood that millions of planets are scattered throughout our Milky Way Galaxy alone — and more throughout the billions of other galaxies. Further support comes from theories of chemical and biological evolution which predict that life will arise on planets where conditions are right. Given sufficient time, some of this life will develop intelligence — which in turn may result in technologically advanced civilizations. Lastly, a presumed need to communicate with other life forms will lead to their transmission of electromagnetic signals, which we might someday detect.

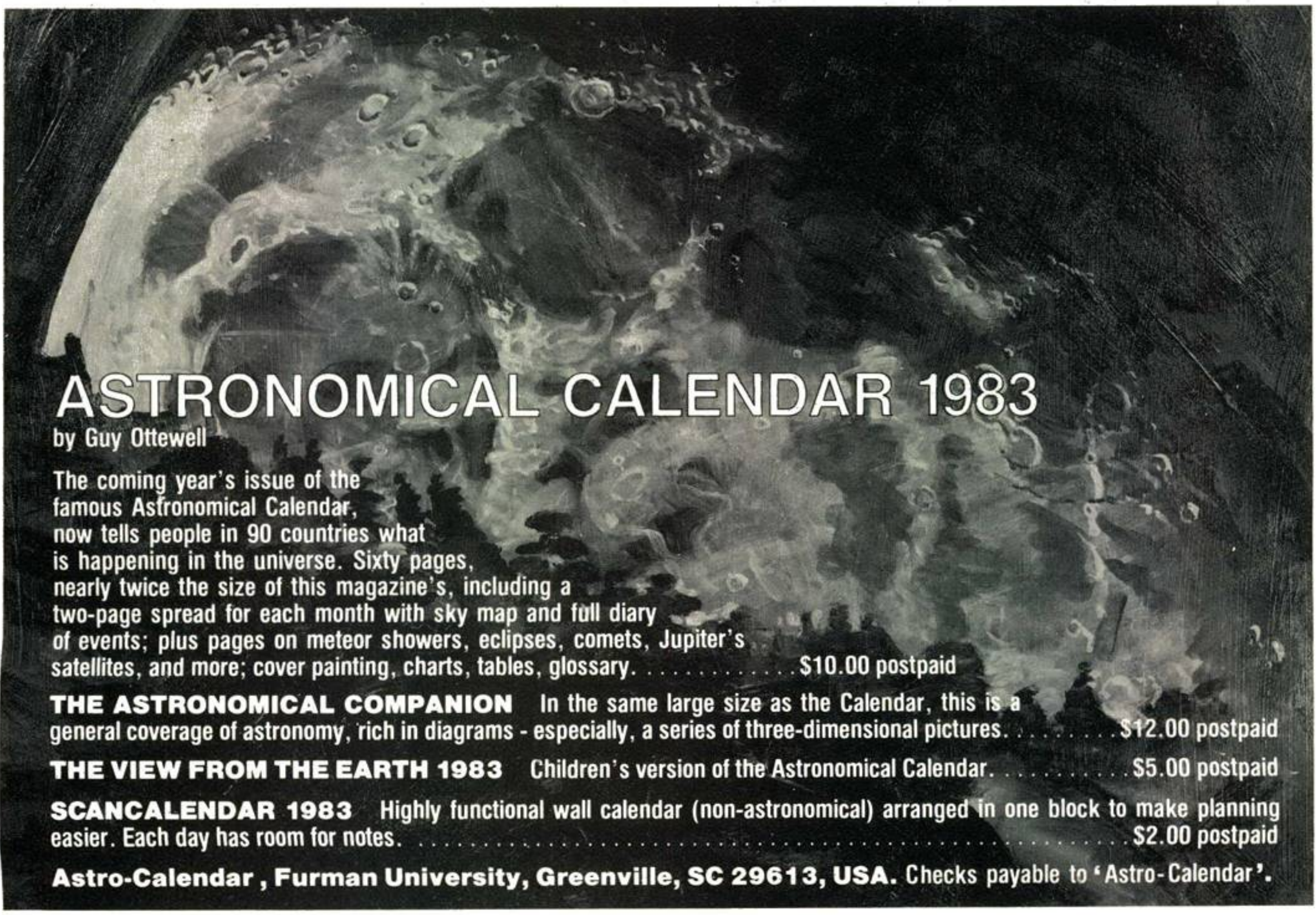
Since the components of the solar system resulted from the chemical evolution of interstellar matter, the authors of the book feel that studying Earth and its neighborhood is the proper step to understanding extraterrestrial life. Thus, for example, we can study hurricane clouds to better understand galactic formations as they have some similar structural characteristics. Similarly, the study of the evolution of oxygen and ozone in our own atmosphere may lead to a clearer understanding of other planetary atmospheres.

Robert Frosch, NASA administrator at the time of the conference, echoed the feelings of the majority there with this statement: "The idea that searches, gropings for knowledge whose purpose we do not understand, are silly and some kind of rip-off results from sheer lack of understanding, lack of imagination, and lack of perception of the meaning of the history of the human race."

Life in the Universe is filled with serious studies, some rather technical; to understand clearly every concept and nuance in the book, you'll need a grasp of basic chemistry and physics. Still, anyone with an interest in research into extraterrestrial life can profit from the book. And it cites enough references to send the motivated reader to a wealth of additional material.

The diversity of authors drawn together by the conference ensures a broad range of perspectives and style. One contributor refers to planets as "cosmic Petri dishes." Another offers a tongue-in-cheek guideline for the evolution of life forms: "My advice to any aspiring young life form seeking a safe place in the Galaxy would be similar to the advice a father might give his son as he prepares to venture into the world: 'find a good stable star of 0.8 to 1.2 solar masses, settle down, avoid crowds, and above all, stay away from hot, young heavenly bodies'."

Many books on extraterrestrial civilizations couple a high degree of literary license with a heaping measure of guesswork. Thus it is refreshing to find a work which proceeds carefully, closely examining our own planet and building on existing knowledge of



ASTRONOMICAL CALENDAR 1983
by Guy Ottewell
The coming year's issue of the famous Astronomical Calendar, now tells people in 90 countries what is happening in the universe. Sixty pages, nearly twice the size of this magazine's, including a two-page spread for each month with sky map and full diary of events; plus pages on meteor showers, eclipses, comets, Jupiter's satellites, and more; cover painting, charts, tables, glossary. . . . . $10.00 postpaid

THE ASTRONOMICAL COMPANION In the same large size as the Calendar, this is a general coverage of astronomy, rich in diagrams - especially, a series of three-dimensional pictures. . . . . $12.00 postpaid

THE VIEW FROM THE EARTH 1983 Children's version of the Astronomical Calendar. . . . . $5.00 postpaid

SCANCALENDAR 1983 Highly functional wall calendar (non-astronomical) arranged in one block to make planning easier. Each day has room for notes. . . . . $2.00 postpaid

Astro-Calendar, Furman University, Greenville, SC 29613, USA. Checks payable to 'Astro-Calendar'.

terrestrial life. Endowed with a controlled, scientific approach, this collection is somewhat reminiscent of Sagan and Shklovskii's *Intelligent Life in the Universe* — but fresher and up-to-date.

Whether we passively wait for signals from otherworldly life or actively employ probes, *Life in the Universe* offers cogent arguments for a sound, continuing state of readiness for contact, if and when it occurs. *Gail O. Clark.*

Editor's note: For a sociologist's view of "A Conference on Life in the Universe," see the Forum article "Parallel Universes: A Tale of Two SETIs," ASTRONOMY, October 1981.

A Bibliography of Astronomy 1970-1979

Robert Seal and Sarah Martin
407 pages, hardcover, $30
Libraries Unlimited (1982)

The History of Modern Astronomy and Astrophysics; a selected annotated bibliography

David DeVorkin
434 pages, hardcover, $65
Garland Publishing (1982)

Although neither of these works will likely be found in ordinary bookstores, anyone curious about what the best books and articles are on a given topic in astronomy would find consulting them extremely useful. The book by Seal and Martin covers all fields of astronomy and picks up where an earlier (1970) bibliography by D.A. Kemp left off; its entries describe the contents of a book or article and mention how long it is, how many references the author used, and so on. The arrangement is by subject and the headings follow those used in *Astronomy and Astrophysics Abstracts,* a standard reference work.

DeVorkin's bibliography is also descriptive, but far broader in the time span it covers: about 1610 to 1980, though the emphasis lies mostly on works since about 1850. His subject headings are a mix of several previous ones and follow roughly those used by Seal and Martin. In both cases, the headings work well and lead the reader quickly to the area desired. On the matter of content, both books can easily be recommended.

Unfortunately, one big drawback to both books is their cost, which is too high for anyone but specialists and that perennial captive audience of publishers — libraries. But the great disparity in price between these two books, which have essentially identical physical specifications and are aimed at an identical audience, leads you to wonder just how close the relation is between the cost of production and the selling price. Moreover, the Seal and Martin book is typeset, whereas DeVorkin's — over twice as expensive — is "set" on an ordinary typewriter. Why? *Robert Burnham.*

A New List of 450 Deep-Sky Objects

Fred W. Klein
31 pages, paperback, $6.75
Published by the author (1981)
[order: Fred W. Klein, Hawaiian Volcano Observatory, Hawaii Volcano National park, Hawaii 96718]

This book is designed for those who want a short and concise checklist that is easy to use at the telescope. It is arranged by type of object: double stars, nebulae, galaxies, etc. A key to the appropriate maps in the *Atlas of the Heavens* and the *Sky Atlas 2000* is also provided.

Searching Between the Stars

Lyman Spitzer, jr.
179 pages, hardcover, $25
Yale University Press (1982)

Spitzer, an authority on interstellar matter, gave the 1978 Silliman series of popular lectures at Yale; this volume presents them. The topics covered include a survey of stellar evolution from star-birth to star-death, the electromagnetic spectrum, and the interstellar medium and its clues about the evolution of stars.

The Friendly Stars (revised edition)

Martha Evans Martin
140 pages, paperback, $7.95
Van Nostrand Reinhold (1982)

Don Rise and Craig Foltz have brought this popular, early 20th century book on stargazing up to date. This edition preserves much of the older work's spirit and style.

Comets

Laurel Wilkening, ed.
766 pages, hardcover, $29.95
University of Arizona Press (1982)

This volume, the latest in the University of Arizona's space science series, is a work that summarizes the "state of the knowledge" on comets for professional astronomers. Forty-eight authors in 29 papers discuss such topics as the rotation of comet nuclei (Fred Whipple), observations and dynamics of plasma tails (John Brandt), and comets and the origin of life (Cyril Ponnamperuma and E. Ochiai).

MEADE
LUMICON
CELESTRON
ACCUTRACK
KALT CORP.
SMITH-VICTOR
STAR ATLASES
TELEVUE OPTICS
DAYSTAR FILTERS
EDMUND SCIENTIFIC
UNIVERSITY OPTICS
SWIFT INSTRUMENTS
ASTRONOMICAL BOOKS
VERNONSCOPE-BRANDON
BUSHNELL OPTICAL CORP.

YOU CANNOT AFFORD TO BUY A CELESTRON Without Calling Us For The Most Competitive Prices To Be Found Anywhere.

FAST, FRIENDLY SERVICE

FREE PRICE LIST ON REQUEST

Demonstrations by appointment, or call to discuss your specific needs.

OPTRON SYSTEMS

Eugene L. Cisneros
704-706 Charcot Avenue
San Jose, California 95131-2292 USA

Phone: 408-946-4797 daytime
408-923-6800 evening

ASTRONOMY T-SHIRTS

TOP QUALITY
PHOTO SILK SCREEN
ONLY $8.95
3 FOR $25.95

Adult or Children's
Sizes S, M, L, XL

STYLES INCLUDE:
- Andromeda Galaxy (Navy) - #A-1
- Solar Eclipse (Black) - #E-2
- Astronomers Love Heavenly Bodies (Lt. Blue) - #B-3
- Halley's Comet (Yellow) — #HC-4
- Pleiades (Black) - #P-5

OTHER STYLES:
- Crab Nebula (Black) - #C-6
- Morehouse Comet (Navy) - #M-8
- NGC 5272 (Navy) - #N-7
- Planet Earth (Black) — #PE-9
- Space Shuttle (Tan) - #S-10

coming soon
to your local planet:
HALLEY'S COMET
1986

Send to: Super—T
2345 NE 52nd St.
Gainesville, FL 32601

Include $1.50 Postage
Amount enclosed ________
(outside U.S. & Canada — Add $4.50 postage
Please send in U.S. funds)

QUANTITY	STYLE	SIZE	AMOUNT

NAME ________
ADDRESS ________
CITY ________
STATE ________ ZIP ________

VISA

eye on the sky

moon occults mars

by Fred Schaaf

the wanderers

During November all the planets except Mars are within 30° of the Sun and are not observable, but some planet watchers will see a beautiful occultation of Mars by the Moon.

Observers on the Eastern Seaboard have the best view of the November 19 **Mars-Moon** event, although those north of Norfolk, Virginia, (36.4°N) must settle for a superb close conjunction. Farther west the occultation takes place before sunset. A favorably placed observer might see an occultation or grazing occultation with little or no optical aid. Although Mars is faint at magnitude 1.3, the Moon is only four days from new and will not overwhelm the Red Planet with its glare.

The **Mercury-Saturn** pairing on the morning of November 1 will be visible to all North American observers. Mercury won't be seen much longer as it reaches superior conjunction on the 19th. Saturn gains altitude each morning, and reaches a 40° elongation from the Sun by November 30. You can spot Saturn in Virgo, to the northeast of, and moving away from, Spica.

In a period just longer than a month, six planets reach conjunction with the Sun: Saturn, October 18; Pluto, October 29; Venus, November 4; Jupiter, November 13; Mercury, November 19; and Uranus, November 27. Even the minor planet Pallas is at conjunction with the Sun on November 27, and Neptune next month. Only Mars falls outside this concentration.

Unfortunately, many close conjunctions occur while these planets are lost in the solar glare. Most notable is the Venus-Uranus conjunction on the 22nd when both planets are 5° from the Sun, and separated by 1.5 minutes of arc!

You might spot **Jupiter** as an evening object on November 1, and then again in the pre-dawn sky at month's end — but it won't be easy. The favorable angle of the ecliptic on November mornings should allow you to see Jupiter a week after conjunction as it rises before sunup as a -1.2 magnitude "star" in eastern Libra.

While the planets are poorly placed, we can watch the **Leonid** meteor shower. Look for these swift meteors in the last hours before morning twilight on the 17th. You can count lesser numbers a few nights before and after. The Leonids are irregular, so you might see fewer than 10 per hour at the peak.

Sometimes the Earth's orbit intersects a concentrated Leonid stream, and many dozens per hour enter the atmosphere. We are now midway between the 33-year period that coincides with spectacular Leonid outbursts. In 1966 thousands of Leonids rained down, but we'll have to wait until November 17, 1999 to see if that happens again.

Many skywatchers enjoyed July's long lunar eclipse, but if you missed it, you'll have another chance to see an eclipsed Moon next month. November offers two preparatory **Full Moons** to build anticipation — one on the 1st and one on the 30th. Only once in the next five years will two Full Moons fall in the same month.

the starry sky

Six large and bright autumn constellations commemorate seven figures from the same Greek myth. **Pegasus** consists of more than just the famous Great Square asterism. From the Square's northwest corner trace the line of stars that forms the forelegs of this celestial horse, but note the more prominent line that extends from 2nd magnitude Enif in the southwest corner. Not far beyond lies the globular cluster **M-15**, which you can sometimes glimpse with the naked eye.

Pegasus flies upside down in our sky, and his rear legs are formed by two lines of stars that diverge from **Alpheratz** and denote the main pattern of **Andromeda**.

Old star atlases often picture Pegasus half-risen from the sea to account for his missing rear legs. Certainly, these stars, even Alpheratz, officially belong to Andromeda; Mirach and Almach form the line with Alpheratz. Note the different hues of these three in binoculars — can you detect any colors with the naked eye?

Andromeda's faint upper curve is even more interesting because at its mid-point glows **M-31**, the Great Andromeda Galaxy, a superb naked-eye object. In good skies, you may trace the long dimension of this radiance for several degrees. M-31 passes directly overhead on mid-November evenings for observers near 40° N. latitude.

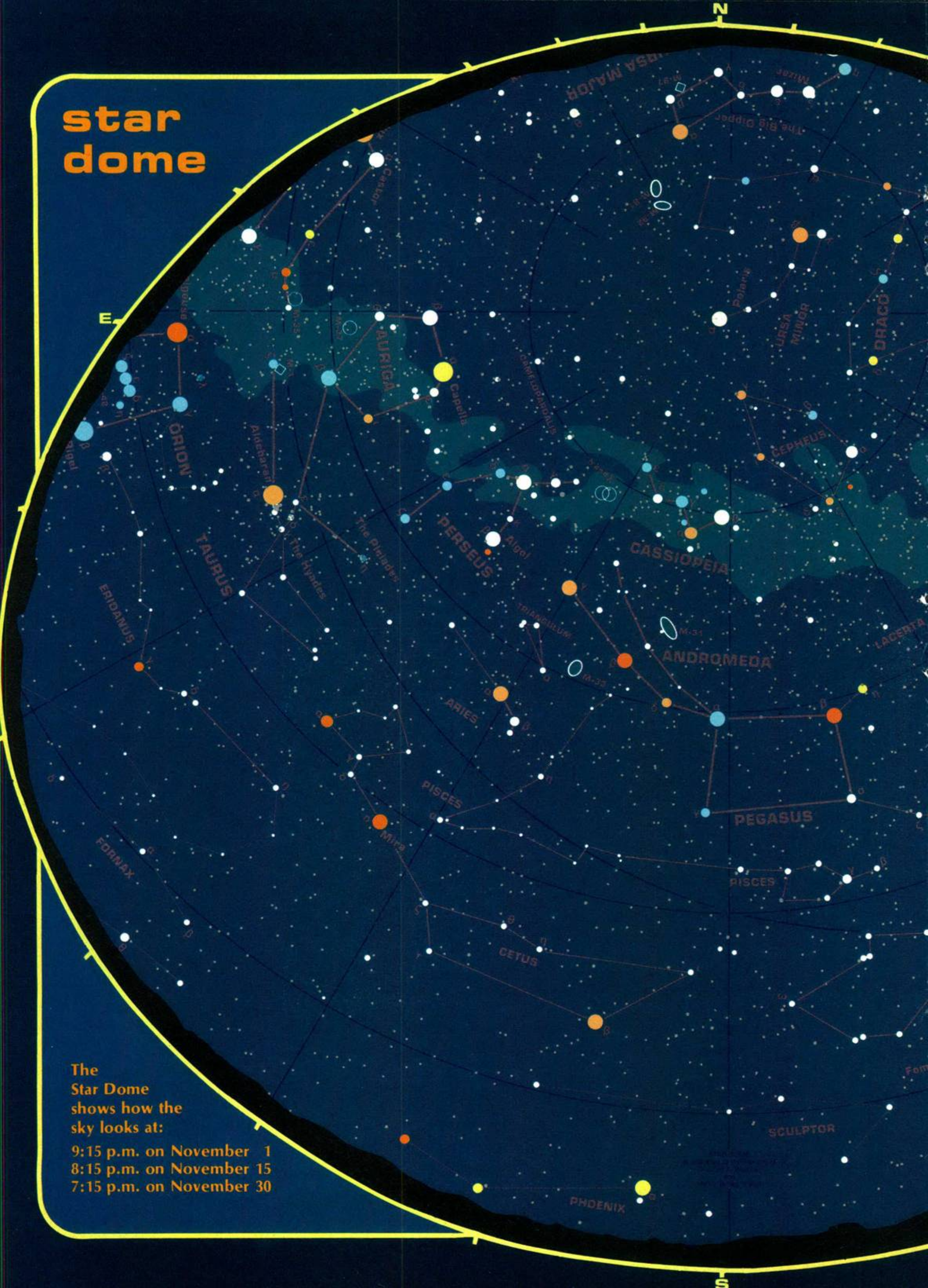
Around midnight you'll see another of fall's intriguing celestial objects close to the zenith — the variable star **Algol**, an eclipsing binary. Also called the Demon Star, Algol may have had its variability noted long before the invention of the telescope. Its 2nd to 3rd magnitude fluctuations seem dramatic enough to signal its unique character to naked-eye stargazers, but it's difficult to catch its show by chance.

Like Andromeda, **Perseus** forks into two legs, has a loop or "helmet" of stars for his head, and extends a long arm with Algol near the end — Algol means "the ghoul" in Arabic, and represents the severed head of the dreadful Medusa.

North of the head of bright Perseus

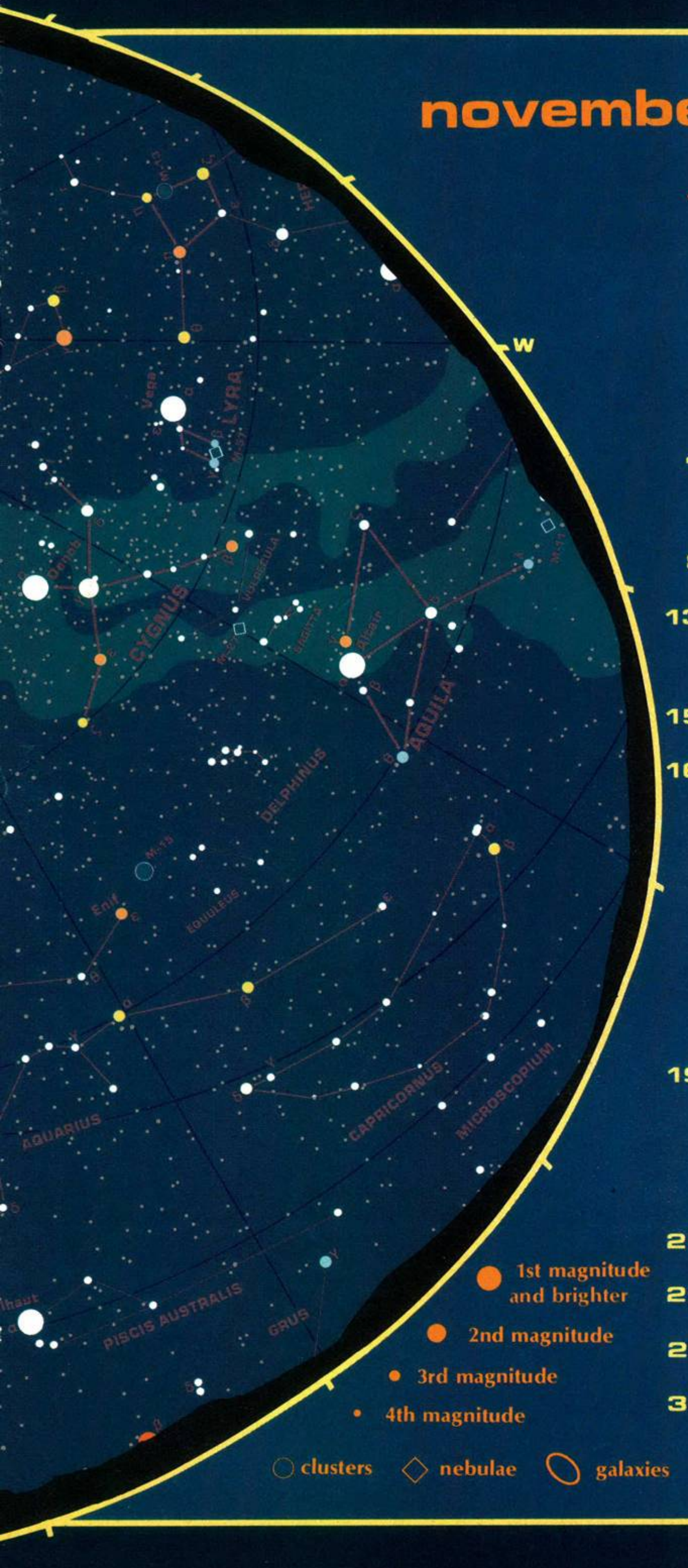
The beautiful Double Cluster that surrounds h and Chi Persei is prominent on November evenings. David Healy photographed it with a 45-minute exposure on ASA 100 film through a 300mm f/4.5 lens. Below: The stars of Taurus trail majestically in this 45-minute exposure by John Foster on ASA 200 film.

star dome


N
E
S
URSA MAJOR
M-97
Mizar
The Big Dipper
M-81
M-82
Castor
Polaris
URSA MINOR
DRACO
AURIGA
Capella
M-35
ORION
Rigel
Aldebaran
CAMELOPARDALIS
CEPHEUS
PERSEUS
Algol
The Pleiades
The Hyades
TAURUS
CASSIOPEIA
ERIDANUS
TRIANGULUM
M-31
ANDROMEDA
LACERTA
M-33
ARIES
PISCES
Mira
PEGASUS
FORNAX
PISCES
CETUS
SCULPTOR
PHOENIX

The Star Dome shows how the sky looks at:

9:15 p.m. on November 1
8:15 p.m. on November 15
7:15 p.m. on November 30


HER
M-13
LYRA
Vega
M-57
W
M-11
Deneb
CYGNUS
VULPECULA
SAGITTA
Altair
AQUILA
DELPHINUS
M-15
Enif
EQUULEUS
AQUARIUS
CAPRICORNUS
MICROSCOPIUM
PISCIS AUSTRALIS
GRUS
lhaut
● 1st magnitude and brighter
● 2nd magnitude
● 3rd magnitude
• 4th magnitude
○ clusters
◇ nebulae
⬯ galaxies

november sky almanac

1st Mercury and Saturn are paired together in the eastern sky this morning just before sunrise. Choose an observing site with a clear horizon and be prepared to look carefully. You won't have very long to observe before the Sun makes the sky too light for good viewing. (Binoculars will help, too.) The Moon is Full at 7:57 a.m. EST.

4th Venus is at superior conjunction. The Moon passes through perigee this morning: 227,090 miles.

8th The Moon will reach Last Quarter at 1:38 a.m. EST.

13th Jupiter is in conjunction with the Sun. In the morning sky, you can see the Moon passing 3° north of Saturn.

15th The Moon is New at 10:10 a.m. EST.

16th The best time to observe the Leonid meteor shower will be late tonight and in the early morning hours of the 17th. Under dark suburban or rural skies, the rate will be around 10 meteors per hour; anyone observing from the city should expect less. Since peak activity comes during the daylight on the 17th, look for the meteors on the night of the 17th/18th as well.

19th Mercury is at superior conjunction. In the evening sky, the Moon will either occult or pass just south of Mars, depending on where you live. (See Eye on the Sky and Backyard Astronomer for details.)

20th The Moon is at apogee this morning: 251,883 miles.

23rd First Quarter Moon is at 3:05 p.m. EST.

27th Uranus is in conjunction with the Sun.

30th Full Moon is at 7:21 p.m. EST.

Jim Misti photographed the setting Sun from Carter Caves Park, Kentucky, at the prime focus of his 8-inch Schmidt-Cassegrain. A Wratten 25 filter and a 1/250-second exposure on ASA 200 film silhouetted the reddened Sun behind a grove of bare trees.

shines **Cassiopeia** and her husband **Cepheus** — the parents of Andromeda in the Greek myth. Cassiopeia is famous for its clusters, but they require binoculars and telescopes. Just outside Cassiopeia's bounds, between her bright "M" pattern and the head of Perseus, is a marvelous pair of clusters visible to the unaided eye — the **Double Cluster** — twin fuzzy glows of magnificent star congregations.

Four constellations of the famous "Royal Family" fill the autumn sky: **Andromeda**, **Perseus**, **Cassiopeia**, and **Cepheus**. Pegasus, the winged horse, is also tied to the legend because he sprang to life after Perseus' boldest act. But one other character from the Perseus tale also appears in the fall heavens: **Cetus**, the sea-monster.

Cetus' location is fitting: well apart from the Royal Family, he lurks in the region called the Water or Celestial Sea. Cetus' neck is marked by the classic long-period variable, **Mira** — the wonder. This year Mira reached maximum in July and now has faded to obscurity. On rare occasions, Mira outshines the other stars of Cetus — Diphda in the tail, and Menkar in the head. The head of Cetus is an easy asterism to spot and will help you identify this lonely monster.

The constellations that form a buffer between Cetus and the Pegasus-Royal Family group include two members of the zodiac — **Pisces** and **Aries**. Aries features second magnitude **Hamal**, but the Ram's main figure has few stars. Pisces' pattern is even harder to discern.

As a final sight, go out as darkness falls to a place with a clear northern view. You'll see the **Big Dipper** scraping along the horizon — directly between **Capella** in the northeast and **Arcturus** in the northwest. About 90 minutes later Polaris lies between Vega and Capella. *You'll also see the* **Pleiades** and orange **Aldebaran** in the east.

skylore

Last month we left Perseus after his successful visit to the three old wisewomen, the Grey Ones from whom he learned the way to Hyperborea.

But where was Hyperborea? Perseus found out, but scholars are still uncertain where it was. Most likely, this wonderful country existed, in the potent phrase later used by George MacDonald, "at the back of the north wind." But Hyperborea was not a frigid land; it was a paradise where the Hyperboreans spent their time feasting and in merriment. Legends tell us the people there lived for a thousand years.

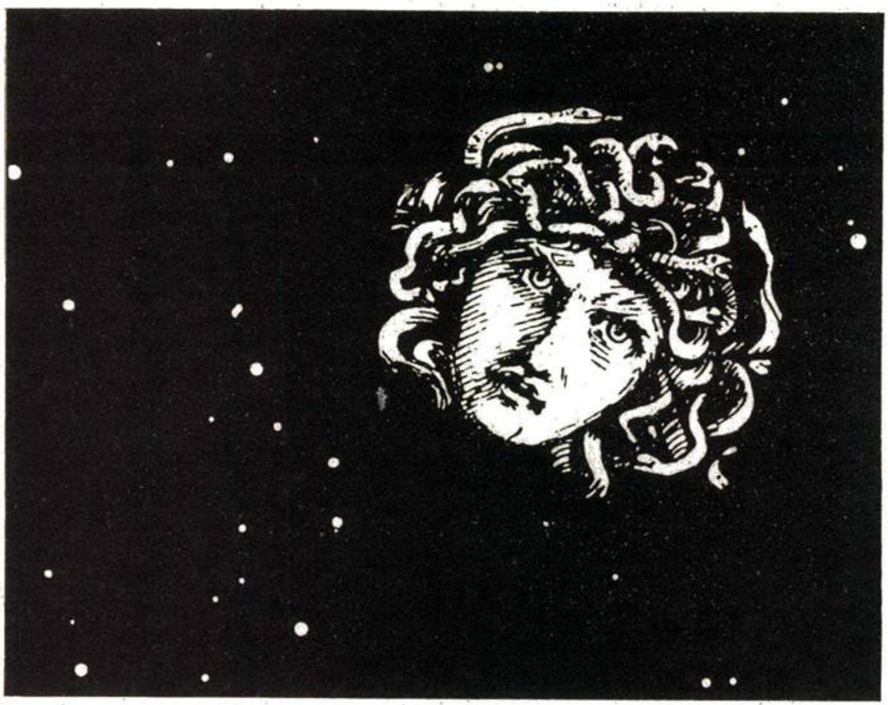
The Hyperboreans greeted Perseus with courtesy and supplied him with the mighty devices that Athena said he needed. Perseus already had Athena's shield, and he had flown to Hyperborea with the aid of the Shoes of Swiftness which Hermes loaned him. Now the Hyperboreans gave him the Sword of Sharpness, which could cut through Medusa's scales; the Cap of Darkness, that turned its wearer invisible; and a magic wallet that changed size to enclose any object.

And so Perseus soared away with grim resolve from a land of laughter and plenty, bound for the Dreadful Isle, the home of Medusa and her Gorgon sisters. He put on the Cap of Darkness and glided silently toward the island, surveying the scene in the highly polished shield Athena gave him. The reflection of the Gorgons would not turn a man to stone although a direct view of them would. On the shield's surface he gazed and beheld what the tales had foretold — the shapes of three monstrous sisters. Luck was with him, for all three seemed asleep, their vigilance relaxed.

Perseus summoned up all his courage and swept down like a wind from the north. While gazing in the mirrored shield he swung one mighty stroke with the magic Sword and hewed off Medusa's ghastly head.

Blood boiled from the neck in a thick fountain, and drops flew from the severed head as Perseus, eyes still averted, seized the head by the writhing and spitting snakes that were its hair. From the poisonous droplets of blood sprang up two wonders: the warrior Chrysaor and the winged horse Pegasus, both of whom Medusa had conceived before her transformation; she had been unable to bear them because of her cruelty.

Now peril was upon Perseus, for Medusa's immortal sisters were awake. With shrieks and bellows of wrath, the remaining Gorgons shot up into the air. Their brazen claws outstretched, their cruel deadly faces glaring, the horrible sisters searched for Perseus.



He thought they would catch him as they whirled by, stabbing the air with their eyes' hatred, but the Cap of Darkness hid Perseus. He thought they would hear him and overtake him with their speed, but he outpaced them with the Shoes of Swiftness. He never looked back until he was far away, and then at last Perseus knew he had done the impossible — he had escaped with Medusa's head.

But Perseus' adventures were not over. His flight back to Seriphos where his mother waited in danger took him over the city of Joppa, ruled by Cepheus and Cassiopeia. That land was in an uproar because Cassiopeia had boasted her beauty was greater than the sea-nymphs of Poseidon. As punishment, the nymphs asked Poseidon to send a sea-monster to devastate the kingdom. This beast would exact the nymphs' revenge on the whole populace until Cassiopeia and Cepheus sacrificed their only daughter, Andromeda, to the monster.

They had no choice but to chain the poor maiden to the sea-cliffs and await the monster's coming. As the tide rose Cetus appeared, surfacing with a deep thunder, his vast bulk shouldering the waters of the Mediterranean. Suddenly Perseus hurtled down like a meteor to challenge the monster. Cetus could not see Perseus since our hero wore the Cap of Darkness. But how could these magical devices keep Cetus from Andromeda? Not even the Sword of Sharpness could cut through Cetus' bulk, but Perseus did have one mighty weapon.

Taking off the Cap of Darkness, Perseus lured the enraged creature away from shore, flitting just above the waves, and using himself as bait. When he was far enough out, he let the monster come closer. The great jaws opened wide, and when they were almost upon him Perseus turned his face and displayed Medusa's head to Cetus. Even after death it held its paralyzing force and the bellowing monster was instantly frozen, jaws agape, poised forever as a formidable rock off the coast of Joppa. Perseus then freed Andromeda and she fell in love with her rescuer as swiftly as he did with her.

When Perseus and Andromeda returned to Seriphos they found Perseus' mother and foster grandfather hiding from Polydectes, for he had sought to force Perseus' mother into marriage now that Perseus was gone forever. What a surprise it must have been when Perseus appeared at a feast Polydectes was holding with all his supporters.

As Polydectes stood there in awe, Perseus said, "Here is your gift! " and he held Medusa's head up for all to view. A second later the room was a gallery of statues of evil men frozen in horrible death.

And what of the evil grandfather of Perseus? Acrisius had long since fled his kingdom, but one day Perseus attended an athletic competition and hurled a javelin that went astray and killed a spectator. Who was this person? Acrisius, of course. And so the death foretold for him came true, despite all of his efforts to evade it.

The rest of the life of Perseus and Andromeda was happy. They ruled their land wisely and had many children. One of their great grandsons was Hercules. But most important of all, the tale of their lives endures as the most star-honored of all time.

PRECISION OPTICS

GIANT BINOCULARS

Celestron offers a complete line of binoculars for all applications. The 11x80's (11 power magnification and lenses 80mm in diameter) shown above are from our giant series that excel in giving you bright, detailed views of the starry night sky. We also have ultra compact roof prism designs and classical models.

C5 TELESCOPE

Celestron's dealers offer the World's lightest and most compact 5-inch diameter Schmidt-Cassegrain telescope. The C5 weighs only 13 lbs! The C5 will show objects significantly better than 3½ or 4-inch telescopes, yet, it is hardly any larger. The C5's optical tube easily mounts on a tripod to use as a superb spotting scope or as a 1250mm f/10 telephoto! Remember, every Celestron from the C90 to the C14 can be used to view or photograph objects in the sky or on the ground.

CHRISTMAS GIFT SUGGESTIONS

New Accessories

ADJUSTABLE HEIGHT TRIPOD—for C90/C5/C8 (Available Dec. '82)

CELESTRON SKY MAPS—where to locate objects in the sky

CELESTRON PLOSSL EYE-PIECES (*Ultra High Quality*)—1¼" size only: 8, 10, 17, 21, 26, 36, 45mm focal lengths (Available soon)

SETTING CIRCLE LIGHTS

C65 SPOTTING SCOPE—65mm diameter spotting scope for terrestrial applications (Available Dec. '82)

Contact Your Celestron Dealer For Prices And Details

ANNOUNCING A MAJOR NEW SERVICE FOR TELESCOPE USERS AND

1-800-

- Call Toll Free
  (within the Continental USA)
  M–F, 8AM to 4PM
  (Pacific Time Zone)

- Dealer Locations
- Product Information
- Educational Aids

FROM **CELESTRON®**

for *Adventure* in Astronomy

C11 TELESCOPE

We've made some changes in the C11 and our manufacturing technology. We can now offer the same superb optical and mechanical quality telescope at a lower price. See our ad on the back page for a more portable telescope, the World's most popular telescope, the C8.

C14 TELESCOPE

For the real telescope enthusiast and astrophotographer the C14 was designed to provide a large, transportable telescope. The C14 with its 154-inch of focal length (3910mm!) is utilized by advanced amateurs and schools around the World. Electric positioning controls are standard!

BUYERS: A TOLL-FREE TELESCOPE INFORMATION SERVICE!

421-1526

- **Technical Assistance**
- **Get Friendly Help When Selecting a Telescope**

CELESTRON®
2835 Columbia St.
Torrance, CA 90503
213-328-9560

FOR MORE INFORMATION
If you want more information on Celestron's Accessories and Telescopes, please write to us.

CELESTRON INTERNATIONAL
P.O. Box 3578-B, 2835 Columbia Street,
Torrance, CA 90503 (213) 328-9560

ADDRESS

Name

Address

City

State Zip

CELESTRON:

☐ Send me your **FREE** telescope brochure and information.
☐ Send me your 16-page Binocular brochure ($0.50)
☐ Send me your 32-page accessory catalog ($2.00)
☐ Send me your 52-page color catalog ($3.00)

THANK YOU!

IMITATED BUT NOT YET EQUALLED

RV-6 6-INCH DYNASCOPE®

There Is Simply Nothing Like It At Anywhere Near Its Price

Including... Electric Drive, 2 coated eyepieces (threaded for filters), setting circles, 6x30 finder, rotating tube and more.

See For Yourself Why This Famous RV-6 Dynascope May Well Be The Most Popular 6-Inch Telescope In The World Today

More amateurs, professionals, schools and colleges have bought it, used it, recommended it and endorsed it than any other kind. It has been proven in use far beyond any other.

Recognition of the RV-6 among schools, colleges, professionals and expert amateur astronomers is beyond question. No other instrument of its kind has been more proved in use or more widely praised and enthusiastically accepted. Thousands upon thousands of RV-6 Dynascopes prove our engineering leadership. Certainly, more 6" Dynascopes are in use throughout the world today than any other competing model.

Yes, there must be good reasons why more people have chosen it, more experts endorse it than any other 6" Newtonian. And the reasons for its overwhelming Number One rating are simple: more quality, more performance, more value.

Consider, for instance, the superb optical system accurate to better than 1/10 wave, which flawlessly resolves even the most difficult objects with breathtaking ease. Or the heavy duty equatorial mount in which all castings are precision machined to better than .001," providing the stability so necessary for satisfactory viewing and long exposure astrophotography. Because of superb design and precision construction, the entire instrument is as completely rigid and wobble-free as it is simple and easy to use. All materials, long tested in field use, meet extreme durability standards—right down to our new solid stainless steel declination shaft which cannot rust even through a lifetime of use. In comparing value, what other telescope in this price range offers the everlasting quality and close tolerances of solid stainless steel? Or the extra value of Achromatized Symmetrical eyepieces of Plössl quality (superior to both Ramsden and Kellner types), whose brass barrels are threaded to accept filters? Then again, what other telescope in this price range or higher offers you a 60-day unconditional guarantee of satisfaction to back up its advertising claims?

Yet, modern production engineering holds the costs to levels that permit our remarkable price of $359.95, complete—not for a "stripped" model, but for the fully equipped RV-6 Dynascope that has won such unprecedented user pride and loyalty. You can order your RV-6 today with complete confidence that it will live up to your expectations in every way, or we will refund every cent you paid for product under our unique 60-day money-back guarantee. Send your check or money order today.

You Could Pay $100 More Without Getting All These Superior Features
(Except on Another Dynascope)

1. Exquisite Optical System—Includes f/8 6-inch parabolic mirror accurate to better than 1/10 wave, zircon quartz coated, guaranteed and proven in use to be the finest 6-inch Newtonian optical system obtainable—even when compared to 6-inch telescopes costing far more.

2. New Dyn-O-Matic Electric Drive with smooth self-acting clutch that engages and disengages automatically as you seek different objects. Will not interfere when manual operation is desired. Safety housed case. Plugs into ordinary AC socket.

3. Two High Performance Eyepieces—70X (18 mm.), Symmetrical; 140X (9 mm.), 1¼" dia., precision threaded, coated. Also available, extra Symmetricals: 40X (30 mm.), $25.00; 100X (12.7 mm.), $25.00; 180X (7 mm.), $25.00; 220X (6 mm.) Orthoscopic, $28.00; 320X (4 mm.) Orthoscopic, $28.00; 16.3 Erfle Wide Angle, $35.00; CP4 Achromatic Barlow to double powers, $22.50. All give sharpest images to extreme edges. Brass barrels of all Criterion eyepieces are threaded for filters.

4. Solid New Equatorial Mount—Precision machined to better than .001", assuring pillarlike stability during observation or long exposure work. No annoying side play or wobble. Solid Stainless Steel Declination axle can never rust, unlike other 6-inch telescopes. Adjusts easily to any latitude.

5. Setting Circles for both Right Ascension and Declination. Handsomely engraved and finished in fine aluminum. Read directly into the sky for easy acquisition of faint objects.

6. 6x30 Finderscope, Achromatic, Coated, with accurate crosshairs and precision micrometer screw focus. Focus "stays put" unlike sliding draw tube spy-glass types. 6 adjusting screws provide positive collimation.

7. Rotating Rings for Maximum Versatility and Viewing Comfort—Solid-cast, chrome finish, rings are generous 1" wide with felt lining. Newly designed construction, with over-sized knurled adjusting knobs, affords maximum rigidity and allows for quick disassembly and portability, with or without tube.

8. Strikingly Handsome, White 50" Bakelite Tube with porcelainized Duralite finish, durable yet light. Walls are 1/8" thick, completely insulated and anti-reflective blackened inside. Dimensionally stable, maintains perfect collimation at all times.

9. Brass Rack-and-Pinion Eyepiece Holder has precision-cut worm and gear for easier, smoother, more positive focusing. Takes standard 1-1/4" oculars, negative or positive.

10. Strong, Vibration-Free, All-Metal Tripod with easily removable legs. Provides sure, steady support, plus lightweight portability.

11. Excellent Photographic Capabilities—Factory settings for both prime focus and eyepiece projection astrophotography are included upon request at no extra charge! Superb lunar, planetary and deep space photos are easily obtainable by the average amateur.

12. Optional Accessories—A complete system of optical accessories is available to cover the amateur's every need, including drive correctors, camera adapters for both prime focus and eyepiece projection work, eyepieces, filters, and more.

CSi Criterion Scientific Instruments
620 Oakwood Ave., West Hartford, Conn. 06110
Manufacturers of Quality Optical Instruments **203-247-1696**

Model RV-6 Complete with Dyn-O-Matic Electric Drive and All Features Described Below

$359⁹⁵ F.O.B. Hartford, CT

Back By Popular Demand... Model RV-8

Identical to the RV-6, but includes a manual declination slow motion, longer declination axle, extra counterweight and of course an 8" f/8 optical system.

$589.95

$15 Crating Charge

PROOF IS IN THE USING —OUR GUARANTEE

When comparing telescopes, be sure to compare guarantees. Be cautious of guarantees whose time limit does not permit ample time to thoroughly evaluate the telescope. For instance, a new telescope owner may frequently require several weeks or more to get used to his instrument before a defect is found (remember also that atmospheric conditions may prevent optical testing for long periods of time). For this reason, we give you a 60-day money-back guarantee. During this period, if you find the RV-6 is not everything we advertise it to be, if it does not measure up to other 6" telescopes you compare it to, you can return the instrument for a full refund. Please return product freight prepaid, insured, properly packaged and marked Attention Customer Relations Department, Criterion Scientific Instruments. Our guarantee is your assurance that the RV-6 is the best 6" Newtonian you can buy.

Criterion Scientific Instruments
Dept. CAS-117, 620 Oakwood Ave., West Hartford, CT 06110

☐ Please send me, under your unconditional guarantee, the RV-6 6-inch Dynascope. Payment of $359.95 is enclosed.

☐ Please send me, under your unconditional guarantee, the RV-8 8-inch Dynascope. Payment of $589.95 is enclosed.

☐ Charge to my credit card
☐ American Express ☐ VISA/BankAmericard ☐ Master Charge
Card No. ____________ Expiration Date ____________

☐ Send FREE ILLUSTRATED LITERATURE describing the RV-6 6-inch Dynascope and all other telescopes in the Dynascope line.

☐ Send FREE ILLUSTRATED LITERATURE on your new DYNATRACKER Variable Speed Control for RV-6 or other electric drive telescopes.

Name (Print) ____________ Signature (If credit card) ____________
Address ____________
City ________ State ________ Zip ________

photography
in
astronomy

astrophotography: readers' reports

a 12½-inch ritchey-chretien

by Alfred Lilge

Unlike a Messier Marathoner who might observe a hundred objects in one night, a photography enthusiast needs a stable mounting and a flawless precision drive for his telescope. So after 30 years interest in astronomy and 15 years experience in telescope design at Boller and Chivens, I finally built a telescope to pursue my favorite hobby — astrophotography.

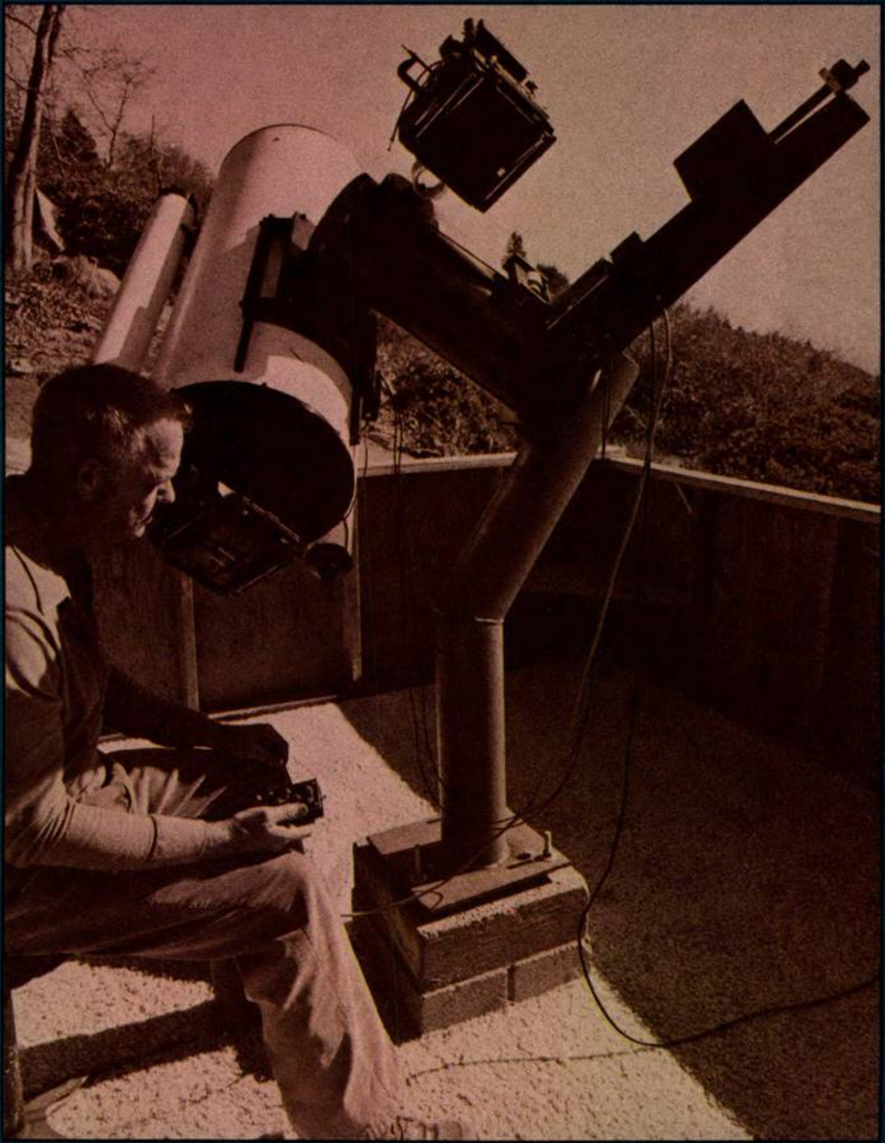
We astrophotographers choose only a few photographic targets per evening, and then must wait until the quarry rises above the lights and pollution near the horizon, so a telescope designed solely for photography requires a different approach than one for general observing.

The best results come when we shoot deep-sky objects as they cross the meridian because the atmosphere is steadier and the sky is darker. To help photograph in this position, my mounting features an extended polar axle that prevents the tube from bumping into the base as I track a celestial object across the meridian.

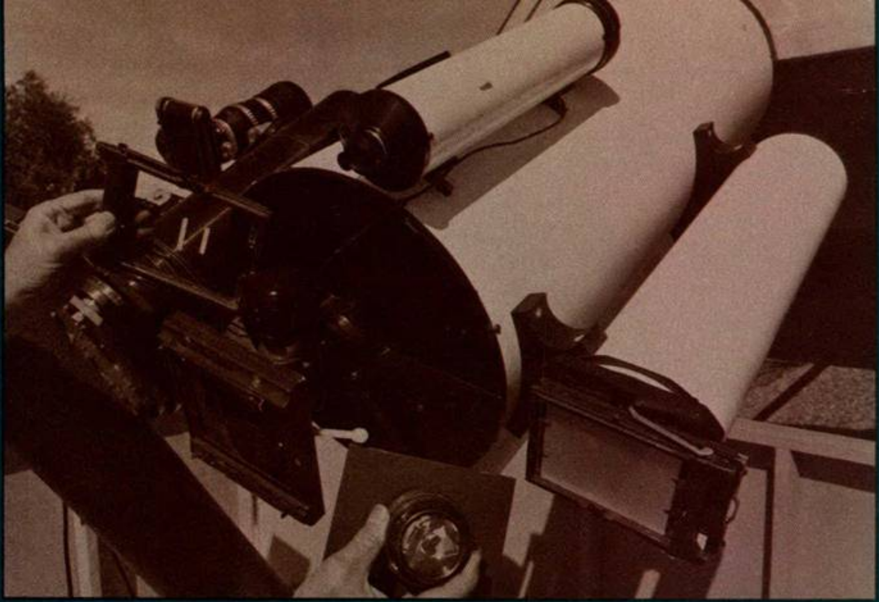
The Telescope

I built a 12½-inch f/8 Ritchey-Chretien Cassegrain telescope, because observatories use that design more than any other. The Ritchey-Chretien emerged in the late 1920s from the prototype of two Mt. Wilson optical designers. It is especially suited to astrophotography because the focal plane is easily accessible and the f/number is moderately fast. Of course, the scopes perform well visually too.

The short tube of the Ritchey-Chretien design also lets me swing the tube from east to west around the polar axle when I gaze straight overhead — unlike a longer Newtonian with a German equatorial mount that's difficult to use when pointed



An inside view of Alfred Lilge's observatory shows his 12½-inch Ritchey-Chretien and its auxiliary photographic equipment.



The rear of the main scope boasts (from left to right) a 35mm camera with a 180mm lens, a 3-inch finder, and a 4-inch f/6 astrographic reflector. Connected to the prime focus of the 12½-inch are the off-axis guider and the plate holder showing the knife-edge focuser.

straight up. The counterweight lies at the south end, and I placed an auxiliary mounting-plate for small cameras at the west end of the declination axle. These design modifications ease guiding problems when the deep-sky object is directly overhead.

Film Size

Choosing the best film format for my custom scope took a lot of thought, and my experience with commercial photography led me to 4x5-inch film. Since it comes in sheets, I don't have half a roll left in my camera until the next clear night. And after I make the exposure, I can go to the darkroom, process the single sheet, and immediately see the results.

You can buy 4x5-inch film at almost any camera store since it's popular with professional photographers. But the types of emulsions that astronomers use to record faint light rays from distant objects differ from those used in the studio. You must order special astronomical emulsions from Kodak if you want the best results.

Kodak manufactures small runs of special emulsions on glass, but not on film, so glass plates are the least expensive way to buy 4x5-inch astrophotographic emulsions. The mimimum order for glass plates is a box of 36, and you should specify the anti-halation "backed" type to eliminate the rings that form around bright stars when light passes through the emulsion and reflects off the back side of the plate.

You can special-order these backed plates from any large photo dealer in your area, although you're bound to get some curious looks when you ask for them. Expect to wait at least 60 days for delivery, and as with all astro emulsions, store them in a freezer unless you're going to shoot them right away.

Unlike sheet film, plates don't have notches on the edge to identify the emulsion side. They are carefully packaged back-to-back, with a paper separator between the emulsion sides. Although identifying the emulsion is not usually a problem, you might lay one down and forget which side is which. If this happens, gingerly touch one side of the plate with the lightly-moistened tip of your finger (use a corner of the plate). The emulsion side will give a little tug, like masking tape feels to the fingers.

Kodak offers three special black-and-white astro emulsions with selective spectroscopic response for use with certain objects: 103a-F, 103a-O, and 103a-E — the "a" stands for anti-halation. I use 103a-F with a red filter for emission nebulae; 103a-O is blue sensitive and good for galaxies; and 103a-E is an all-around film for long exposures that I use when piggybacking. These emulsions are most sensitive at low-light levels, and exhibit the least amount of reciprocity failure — a film characteristic that causes speed loss during long exposures.

Photo Methods

Piggy-backing is an important part of astrophotography, and large format negatives of star fields produce beautiful portraits. I use an old press photographer's tool, a 4x5-inch Speed Graphic camera, with a 150mm f/5.6 lens. It covers 30°x40° vistas of the Milky Way, with breathtaking results. I enlarge the image two times for an 8x10 print, and the negatives hold their sharpness up to 16x20 size.

I also use a 4-inch f/6 astrograph to capture 8.3° x 11° fields. These wide-field photos are great for making your own star atlas, because they indicate the object's brightness relative to your night sky, and also its angular size — important information that is

Above: A 45-minute exposure of the Sagittarius Starcloud through a 120mm f/2.8 lens yields an unusually sharp 2¼-inch slide, attesting to the accuracy of the drive. At right is a one-hour prime focus shot of M-42 through the 4-inch f/6 on ASA 400 film. At far right is a tricolor composite of three black and white spectroscopic emulsions, combined in the darkroom with special filters to produce this color photo of the Orion region. All photos with this article are by the author.

sometimes difficult to derive from star charts or catalogs.

The back of my scope features 4x5-inch camera backs, an off-axis guider, a manual shutter, and a viewing eyepiece for accurately centering the object. The camera back for the main scope is from an old Speed Graphic, while the astrograph's is home-made out of wood. I replaced one ground-glass screen with clear glass and stuck a strip of tape on it that I use as a knife-edge focuser.

I load the glass plates into their holder and insert them behind the spring-loaded ground-glass retainers on the astrograph. Then I remove the dark slide and expose the film using either a lens cap, a manual shutter, or an old hat.

At the end of the declination axle, I mounted a 2¼-inch camera with a 180mm f/2.8 lens that I use with Ektachrome 400 film. With this combination I can photograph the same object three different ways: a detailed black-and-white portrait through the main optics, a wide-field shot including the surrounding sky, and a beautiful color image.

I've also experimented with hypersensitized Technical Pan 2415 film soaked in forming gas (92% nitrogen; 8% hydrogen) for 24 hours at 55°C. This technique produces a fine-grain negative, but with only half the speed of 103a plates. I tried longer soaking times, hoping to bring the speed up to that of 103a, but it produced too much fog and washed out the subtle regions of nebulae. I've exposed 75 sheets of 2415, and it seems to work best for wide-field negatives where it retains detail even though the image is small.

2415 Slides

2415 in 35mm rolls is ideal for making positives for projection (see "Making Black and White Slides," ASTRONOMY, May 1982). I use a black plastic pipe, 3 inches inside diameter and 5 inches long, which I place over a wide-open macro lens. The pipe cuts down stray light that can fog the film. I place the glass plate negative against the end of this pipe with a light source behind the slide — a clear sky works fine. I can easily see the object in the camera's viewfinder, and focusing is no problem.

I set the film speed indicator to the lowest ASA and use the camera's internal exposure meter to adjust the shutter speed. The slides I make with this combination are superior to any print — since film gives a wider tonal range than any paper — and they project beautifully on my living room wall or at a club meeting.

Alfred Lilge works part-time at Palomar Observatory and has been taking astrophotographs since 1950.

film loading tips

by Paul Roques

The 35mm camera is a versatile photographic tool, but it presents one problem for astrophotographers — you can't easily change film until the end of the roll. While professional astronomers use single frames in the form of glass plates, the 35mm astrophotographer must use roll film, even though he might only shoot one frame a night. Then, if it's cloudy for the next two weeks, the whole roll sits in the camera and loses sensitivity.

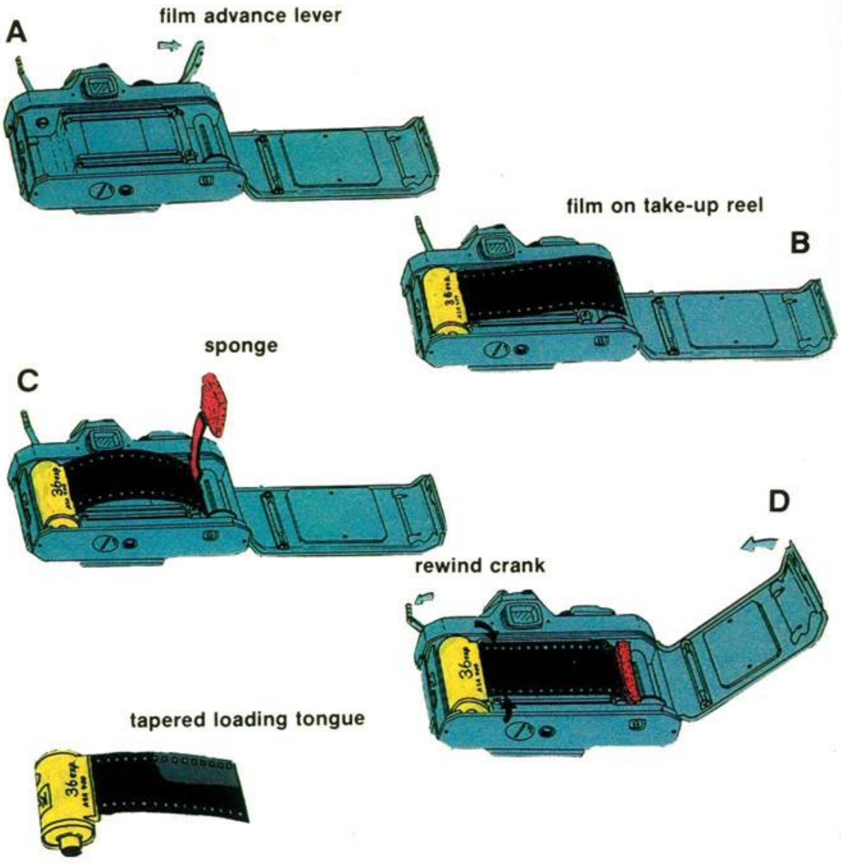
The amateur needs something akin to the observatory's custom-machined plate holder. Since most backyard observers use 35mm cameras, let's look at three solutions for this problem. First, you can own two cameras, each loaded with a different type of film — that's the expensive way. Second, you can rewind the short, exposed section of film back into its 35mm cartridge, being careful not to lose the tapered loading tongue inside. Many careless photographers accidentally wind all the film inside and waste film and money by sending Kodak partially exposed rolls to develop.

If you have rewound carefully, you can easily bring back out the unexposed film without ruining the photos on the beginning of the roll. First cap the camera, and in subdued light alternately trip the shutter and advance the film frame by frame the correct number of times. This procedure is tricky, and it helps to advance one or two extra frames, just in case.

Unfortunately, if you repeat this operation too often, you'll scratch the emulsion — or forget which number you last stopped at. Miscounting those frames can easily result in a double exposure that wipes out your "once-in-a-lifetime" shot.

If those two solutions don't appeal to you, one convenient procedure retains the versatility of photographic plates and allows you to change film types. This technique converts your 35mm camera into a practical and reliable "cut film" holder. To pull it off, you'll need a small piece of pliable plastic sponge 1¼ x 1¼ x ⅜ inches in size, and a film changing bag or a darkroom since you must carry out several steps in total darkness.

The first and most critical step is to cock the shutter and place the camera face down with the back open and the rewind handle extended. Next, snip off the tapered loading tongue, but leave ¼ inch of film projecting beyond the cartridge lip. In total darkness, drop the cartridge into place as for normal loading, and pull out enough film to reach across to the opposite edge. Practice with a dummy roll before using your good film.



drawings by Paul Roques

Tuck the film into the space between the sprocket and the take-up spool. Then shift the film slightly forward or backward until the perforations engage the sprocket teeth. Now wedge the sponge into the space, and you've "locked" the film into position against the sprocket. Note that the excess film arches upward with the emulsion facing down. Dust this strip with a small brush to remove any particles that fell on it during loading.

While preventing the cartridge from rotating, slowly backwind until the excess film tightens against the focal plane guides. Maintain a slight tension on the rewind crank, and, with your forefinger and middle finger, carefully feel that the film is between the two guide rails and engaged with the sprocket.

After you verify the proper positioning, maintain tension while closing the camera back. Be sure to set the speed selector at the desired ASA before you trip the shutter.

To unload the film, open the camera back in total darkness, remove the retainer sponge, and lift out the cartridge. Pull out another inch of film and cut the exposed strip off with a pair of scissors. You now have at least an inch on each side of the exposed frame for safe handling and coding, plus a small amount of film that sticks out from the cartridge for reloading. Remember to write down the ASA of the strip or you'll soon accumulate a number of very anonymous bits of exposed film. If you want to shoot several successive frames, simply cut a new taper on the film and load it normally.

You should learn to process these short film strips at home — something most cold camera and Schmidt camera users do. It's always best to develop your own film, because that's the only way you can be sure it's done right. (See "Developing Black and White Films," ASTRONOMY, February 1977.) After one bad encounter with a careless commercial photo lab you'll quickly realize doing it yourself is the best way.

Paul Roques is an Astronomical Observer at the Griffith Observatory and has been taking astrophotographs since 1943.

ADVERTISEMENT

Meade® Deep-Space Telescope Systems

16″ Equatorial Reflector: **$1185.00**, complete! The Giant-Aperture, Deep-Space Telescope You Never Thought You Could Afford... Until Now

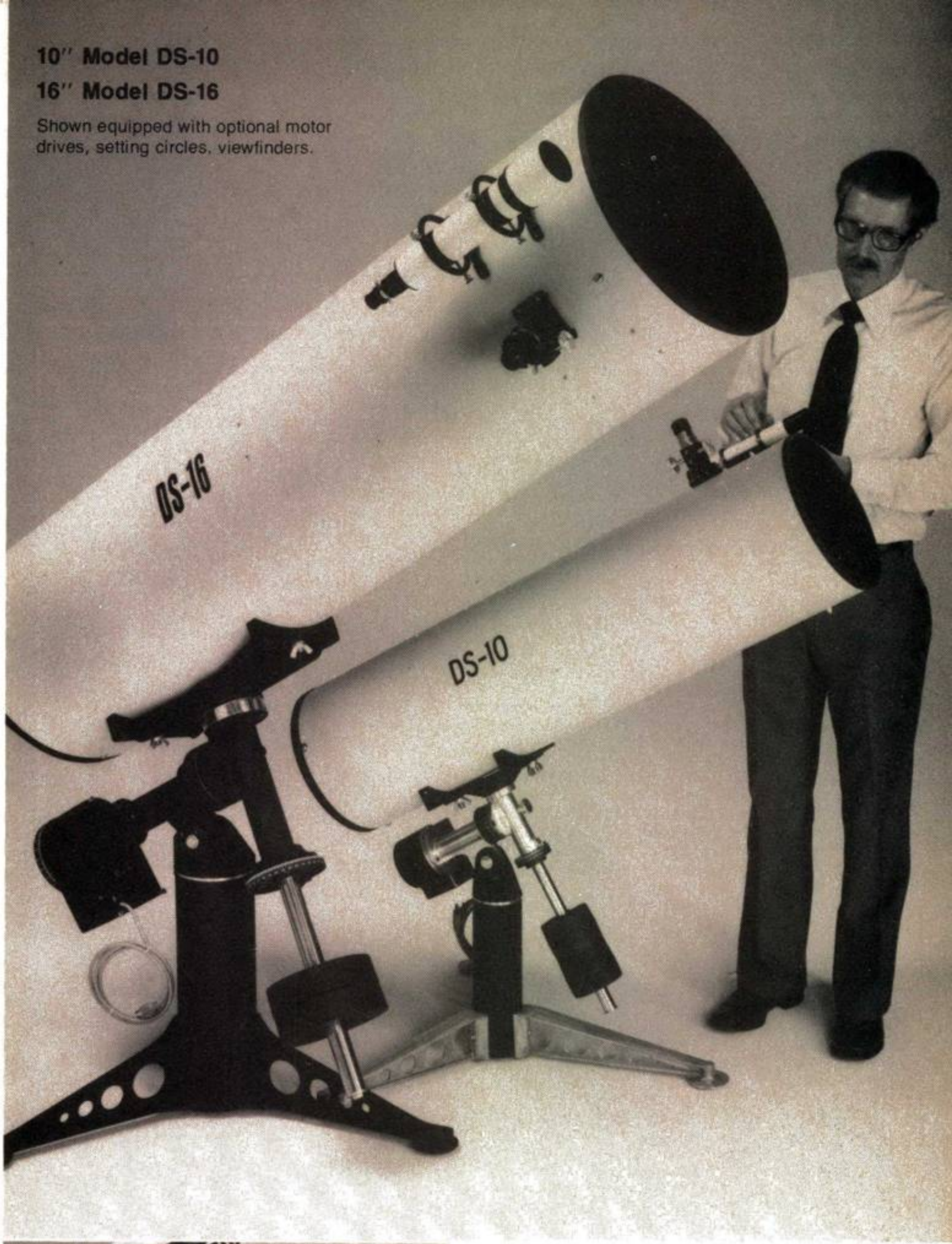
Ever expect to see the Great Nebula in Orion (M42) as a glowing blue-green ember? Or resolve the Hercules globular cluster (M13) to the core? Or observe the dust lanes and spiral structure in the Whirlpool Galaxy (M51)? Not just photographically, but **visually**. Now you can, and can afford to, observe these and countless hundreds of other objects as you've never seen them before. The incredible Meade DS-16, with **50%** more light-gathering area than other 13″ telescopes, has just opened up a new universe for you.

Consider the possibilities in astrophotography: Capture the glowing yellow-red detail of the Ring Nebula (M57), including the 15th-magnitude central star, in **4 minutes;** or the complete red, blue and green structure of the Orion Nebula, including the diffuse outer loop in **6 minutes;** the fiery-red gaseous detail of the Omega Nebula (M17) in **5 minutes;** the dust lanes and spiral detail of the Andromeda Galaxy (M31) in **5 minutes or less!** Exposure times so short you really don't need a drive corrector or guide telescope— so short that even a beginner can obtain astrophotos of exquisite detail.

Manufactured exclusively for Crown Optics by Meade Instruments Corp., the World's largest manufacturer of reflecting telescopes for the serious amateur, the DS-10 and DS-16 make available to the average amateur visual and photographic capabilities only dreamed of until now. Unlike competing large-aperture telescopes, the Meade DS-Series Telescopes include **Equatorial Mounts** as standard equipment: you track effortlessly along **one** axis, not along 2 simultaneous axes as with an alt-azimuth mounting. Add the optional Electric Motor Drive System and you're ready for fully automatic tracking and the deep-space photography you never thought possible.

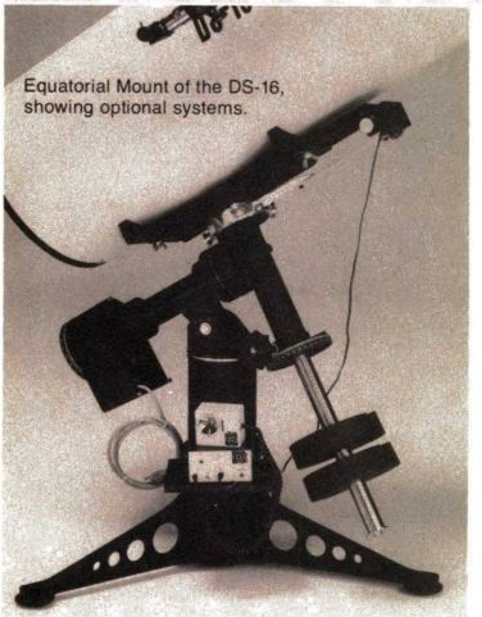
SPECIFICATIONS— Meade DS-10: 10″ f/4.5 Reflecting Telescope. With null-figured, diffraction-limited Pyrex parabolic primary mirror and matching (2.60″ M.A.) 1/10-wave flat elliptical secondary; #67 rack-and-pinion focuser at convenient observing position; Kellner 25mm (46×) eyepiece; Sonotube 12″ I.D. × 46″ long, sealed and attractively Zolatone coated; all-metal, precision-machined Equatorial Mount, with ultrasmooth nylon bearings and 1″ solid steel shafts; rock-solid, low-profile pier and tripod legs; locks on both axes. Complete: **$449.50**.

SPECIFICATIONS— Meade DS-16: 16″ f/4.5 Reflecting Telescope. With null-figured, diffraction-limited, Pyrex parabolic primary mirror and matching (4.00″ M.A.) 1/10-wave flat elliptical secondary; flotation mirror cell; #67 rack-and-pinion focuser at convenient observing position; Kellner 25mm (73×) eyepiece; Sonotube 18″ I.D. × 68″ long, sealed and attractively Zolatone coated; all-metal, precision-machined Equatorial Mount, with ultrasmooth Nylon bearings, 1½″ solid steel shafts, and 5″-dia. polar thrust surface; rock-solid, low-profile pier and tripod legs; locks on both axes. Complete **$1185.00**.



10″ Model DS-10
16″ Model DS-16

Shown equipped with optional motor drives, setting circles, viewfinders.



Equatorial Mount of the DS-16, showing optional systems.

OPTIONAL SYSTEMS

#787	**Electric Motor Drive System (115v./60Hz) for DS-10**	**$ 60.00 ppd.**
#897	**Electric Motor Worm-Gear Drive System (115v./60Hz) for DS-16**	**155.00 ppd.**

See our ad on the next page for the wide array of other optional accessories for the DS-10 and DS-16. These include: higher- and lower-power eyepieces; viewfinders; telenegative amplifiers; nebular filters; drive correctors and photoguide telescopes for long-exposure photography; camera adapters. The giant Meade #680 Focuser may also be ordered in place of the standard focuser on the DS-10 and DS-16. See Bulletin DS for details.

- Both models are **complete** instruments at the prices listed— no additional parts or accessories required to start observing.
- Easy Portability— Field set-up time is about 2 minutes for the DS-10, 5 minutes for the DS-16.
- The DS-10 and DS-16 carry the Meade Full-Year Limited Warranty.
- **Prompt shipment** on both models— Order by mail, or by dialing the Crown TOLL-FREE 800-number. (See next page for details.)
- All prices include packing; F.O.B. Costa Mesa, Calif.
- Delivery direct to your door by U.P.S. or truck freight.
- Send for **Free Bulletin DS,** with full details on these incredible deep-space telescopes, or enclose $3.00 for complete General Catalog of Meade astronomical products. (See next page for details.)

CROWN**OPTICS,** INC.
P.O. Box 8672, Newport Beach, Calif. 92660

Authorized Meade Dealer

For ordering information on the finest telescope accessories and parts, or on complete Schmidt-Cassegrains— all at Crown's super-discount prices— please turn the page . . .

The Widest Range of Premium-Grade Meade® Telescope Accessories, Parts, and Complete Schmidt-Cassegrains—from Crown Optics, America's Number One Superdiscount Source

Order TOLL-FREE on our nationwide 800-number!

PHOTO-GUIDE TELESCOPES— Each with coated, air-spaced objective, rack-and-pinion focuser, diagonal prism, 9mm crosshair eyepiece.
1— **Model 300PG:** D=80mm (3.1"); F=1200mm (f/15) **$185.00 ppd.**
2— **Model 280PG:** D=60mm (2.4"); F=700mm (f/11.7) **79.50 ppd.**
3— **Model 210PG:** D=50mm (2.0"); F=600mm (f/12) **57.50 ppd.**
Mounting Rings: for #210PG .... per. pr. **9.75 ppd.**
for #280PG, #300PG ..... per. pr. **12.50 ppd.**

RACK-AND-PINION FOCUSERS— All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼" eyepiece holders.
4— **Model 67** — Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **$23.50 ppd.**
5— **Model 640** — A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. **$36.95 ppd.**
6— **Model 680** — Accepts both 1¼" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes. **$44.95 ppd.**

ACCESSORY CASES— For secure storage of eyepieces, Barlows, filters.
7— **Model 54:** Thick-wall polyethylene with latch and handle. Holds 7 eyepieces & Barlow, filters. Dims. 12" × 8" × 3¾" **$12.50 ppd.**
8— **Model 50:** Luggage-quality metal case with 2 latches, handle; foam custom fits to your accessories. Dims. 20" × 12" × 6½" .... **$39.50 ppd.**

NEBULAR FILTERS— Revolutionary 3-channel filters block natural airglow & sodium and mercury emissions from city lights. Dramatically improve telescope performance visually and photographically.
9— **Model 907:** 18mm aperture, for .965" O.D. eyepieces **$42.50 ppd.**
10— **Model 908:** 23mm aperture, for 1¼" O.D. eyepieces **$49.95 ppd.**
11— **Model 911:** 36mm aperture, threads directly onto rear-cell of Meade and Celestron Schmidt-Cassegrains. ....:... **$69.50 ppd.**

12— **PHOTO-VISUAL COLOR FILTERS**— Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Thread directly into 1¼" O.D. barrels. Filters may be piggybacked. **#8 Light Yellow—#11 Yellow-Green—#12 Yellow—#21 Orange—#23A Light Red—#25A Red—#47 Violet—#58 Green—#80A Blue—Polarizer (30% transmission).** Each filter: **$7.50 ppd.** Set of any 6: **$43.50 ppd.**— Full set of 10: **$70.00 ppd.**

13— **VARIPAK DRIVE CORRECTOR**— **Model 43:** Supercompact 2" × 3" × 4" design. Fast-slow pushbuttons. Variable speed control. Operates from 12 volts D.C., plugs into standard auto cigarette lighter. The 12-watt output is sufficient for most telescopes to 14" aperture .... **$59.50 ppd.**

14— **VARIGUIDE DRIVE CORRECTOR**— **Model 41:** The finest R.A. drive corrector available. Includes aircraft-type joystick controller for continuously variable correction rates. Variable speed control. Use with any telescope drive rated up to 12 watts. Operates from 12 v. D.C. or 115 v. A.C. **$110.00 ppd.**

15— **6 × 30mm VIEWFINDER**— **Model 631:** Same unit supplied as standard equipment on Meade 6" and 8" reflecting telescopes. Actual field: 4°. Includes coated, achromatic objective lens and crosshair eyepiece. Precise push-pull focusing. Thousands now in use. Bracket, with collimation screws and lock-nuts, included. Bracket fits all tubes 6" to 12½". **$24.50 ppd.**

16— **6 × 30mm RIGHT-ANGLE VIEWFINDER**— **Model 633:** As in (15), but with prism for convenient right-angle observations. Prism may be rotated 360° for maximum viewing comfort. 2-ring bracket included. **$29.50 ppd.**

17— **SERIES 1 KELLNER EYEPIECES (1¼" O.D.)**—High-quality, fully-coated optics housed in chromed barrels threaded for filters. Sold elsewhere for $18.00 to $22.00. **KE 9, 25, 40mm** .... each **14.75 ppd.**

18— **SERIES 1 ORTHOSCOPIC EYEPIECES (1¼" O.D.)**— Well-corrected 4-element designs, fully coated, threaded for filters. Sold elsewhere for $26.00 to $30.00. **OR 4, 6, 9, 12.5, 25mm** .... each **$23.75 ppd.**

19— **SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼"O.D.; MULTI-COATED)**—Custom 3-element designs, precisely corrected for chromatic and spherical aberrations. Finest obtainable under $20.
FOCAL LENGTHS: MA 6,9,12,25mm, 40mm Wide-Field, ea. $18.95 ppd.

20— **MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼" O.D.; MULTI-COATED)**—Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief. **$27.50 ppd.**

21— **SERIES 2 ORTHOSCOPIC EYEPIECES (1¼" or .965" O.D.; MULTI-COATED; PARFOCAL)**— The excellent 4-element high resolution optics of these oculars are all the majority of serious amateurs ever require. Razor sharp 45° fields. Both 1¼" and .965" O.D. sets parfocalized.
FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm .. each $27.50 ppd.

22— **RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)**—The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. 4-element systems, unsurpassed in color correction, resolution, and flatness of field. 45° field. **OR 4, 7, 10.5, 16.8, 28mm** .... **each $42.50 ppd.**

23— **RESEARCH-GRADE ERFLE EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)**— For breathtaking wide-angle observations. 65° fields, parfocalized with our Research-Grade Orthoscopics.
FOCAL LENGTHS: ER 7, 12.4, 15.5, 20mm .... **each $47.50 ppd.**

VIEWFINDERS— With helical focusers for ultraprecise control of image sharpness. Coated, achromatic objectives of new Meade design yield fully corrected images throughout the field. Actual field on 50mm models: 4¼°; on 60mm models: 3½°. Crosshair eyepiece, dewcap, dustcap included.
24— **8×50mm— $46.50 ppd.** Brackets: **$9.75/pr. ppd.**
25— **8×50mm RIGHT-ANGLE— $53.50 ppd.** Brackets: **$9.75/pr. ppd.**
26— **GIANT 9×60mm— $65.00 ppd.** Brackets: **$12.50/pr. ppd.**
27— **GIANT 9×60mm, RIGHT ANGLE— $71.50 ppd;** Brackets: **$12.50/pr.**

28— **RESEARCH-GRADE ERFLE 32mm EYEPIECE (2" O.D.; MULTI-COATED)**— Wide-angle, fully-corrected 65° field. The finest eyepiece obtainable in 2" barrel. **$99.50 ppd.** Adapter Barrel for 1¼" O.D. **$10.75 ppd.**

29— **DELUXE CAMERA ADAPTERS**— Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify your camera brand and either 1¼" or .965" focuser. All 1¼" units are threaded for filters. **Nikon, Canon, Minolta, Pentax K, Konica, Olympus OM, or Universal Thread-Mount** .... **$29.50 ppd.**

30— **2X and 3X TELENEGATIVE AMPLIFIERS (1¼" O.D.; MULTI-COATED)**— Warranted without qualification to be the world's finest Barlow lenses. Full 26mm clear apertures, Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths on any telescope. **2X Model 122: . . $29.50 ppd.; 3X Model 123: . . . $32.50 ppd.; 2X Model 131:** Per Model 122, but for .965" focusers; 18mm clear aperture, Multi-Coated. **$22.50 ppd.**

31— **2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)**— **Model 127:** Made to same research standards as Model 122 above, but mounted in a machined sliding cell, for variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated . . . **$39.95 ppd.**

32— **PARABOLIC MIRRORS**— The very finest. 1/10-wave, diffraction-limited primary mirrors. Aluminized and quartz overcoated. Immediate shipment. **6"f/8 . . . $65.00 ppd.; 6" f/5 . . . $75.00 ppd.; 8" f/6 . . . $95.00 ppd. 10" f/6 . . . $195.00 ppd.; 12½" f/6 . . . $335.00 ppd.**

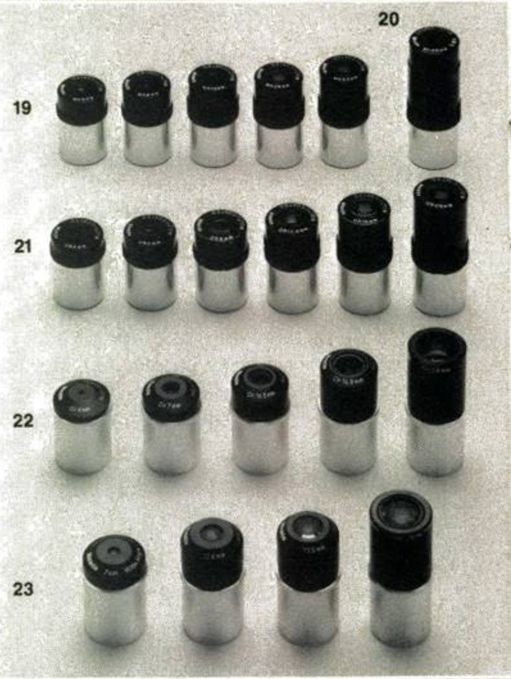
33— **SECONDARY MIRRORS**— Elliptical 1/10-wave flats. Aluminized and overcoated. Immediate shipment. **1.30" M.A. . . . $12.00 ppd.; 1.52" M.A. . . . $16.00 ppd.; 1.83" M.A. . . . $19.50 ppd.; 2.14" M.A. . . . $23.00 ppd.; 2.60" M.A. . . . $27.50 ppd.; 3.10" M.A. . . . $47.50 ppd.**

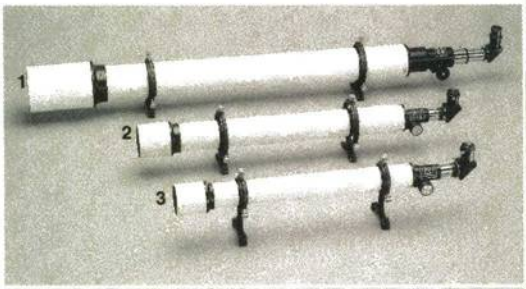
34— **ILLUMINATED RETICLE GUIDING EYEPIECE (1¼" O.D.)**—New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete . . . **$49.95 ppd.** Interchangeable barrel for .965 " O.D. . . . **$7.50 ppd.**

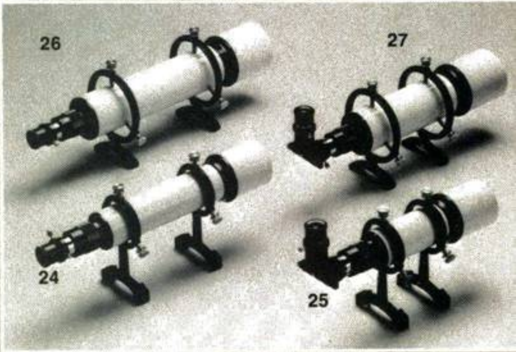
35— **MICROMETER RETICLE**—Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle of Item (34), above . . . **$19.50 ppd.**

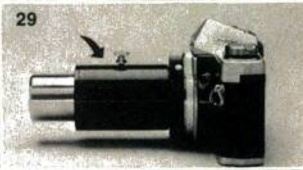
36— **ERECTING PRISMS**—Fully coated Porro prisms. Invert the astronomical image for terrestrial observations with astronomical telescopes. **1¼" O.D. . . . $29.75 ppd.; .965" O.D. . . . $25.75 ppd.**

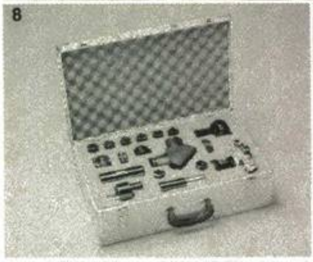
DIAGONAL PRISMS— Optical-quality right-angle prisms, fully coated.
37— **Model 915:** Fits .965" focusers, accepts .965" eyepieces **$16.95 ppd.**
38— **Model 917:** Hybrid diagonal— fits .965" focusers, accepts 1¼" O.D. eyepieces .... **$26.95 ppd.**
39— **Model 918:** 18mm clear aperture. Fits 1¼" focusers, accepts 1¼" eyepieces .... **$22.95 ppd.**
40— **Model 918A:** 30mm clear aperture. Fits 1¼" focusers, accepts 1¼" eyepieces. Enlarged aperture increases field at low power **$26.95 ppd.**

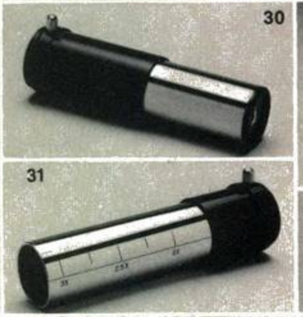


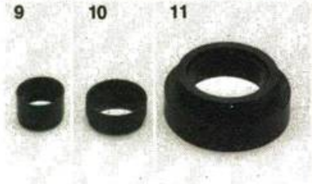


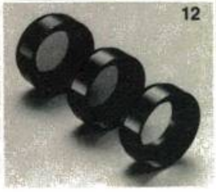


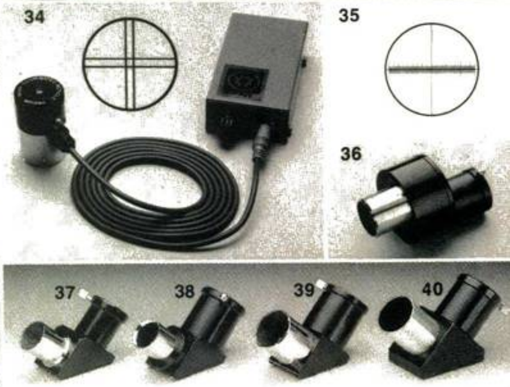


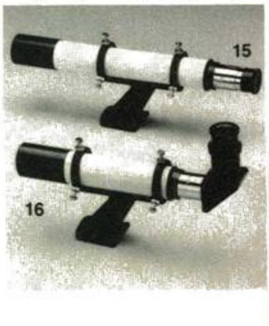


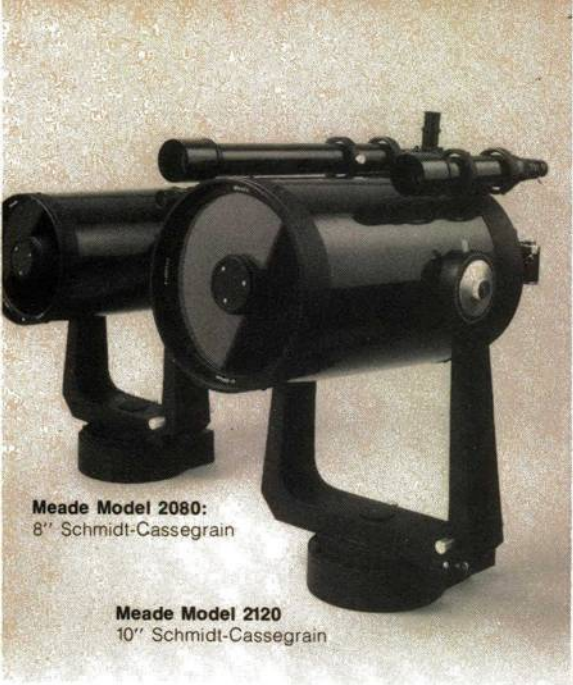












Meade Model 2080:
8″ Schmidt-Cassegrain

Meade Model 2120
10″ Schmidt-Cassegrain

Shown with optional equatorial wedges, field tripods, and astrophoto equipment.

Model 2120
Model 2080

Research-Quality Accessories for Meade and Celestron Schmidt-Cassegrains

All of these Meade accessories are of the finest optical and mechanical quality available, and all (except item H) may be used interchangeably on Meade and Celestron Schmidt-Cassegrains.

PRICE LIST

A—	**Off-Axis Guider Body**	$45.50 ppd.
B—	**T-Adapter**	19.00 ppd.
C—	**Tele-Extender**	19.00 ppd.
	T-Rings (specify camera brand)	each 10.00 ppd.
D—	**Telecompressor Lens** (f/5), Multi-Coated	37.50 ppd.
E—	**Extender Tube** (to use Telecompressor with Off-Axis Guider)	11.50 ppd.
F—	**Wide-Field Adapter Systems** (Visual Telecompressors) Includes Telecompressor Lens, Special T-Adapter, and Diagonal Prism.	
	For .965″ eyepieces	71.50 ppd.
	For 1¼″ eyepieces	77.50 ppd.
G—	**2″ Diagonal Mirror.** Includes adapters for 1¼″ and 2″ O.D. eyepieces	159.95 ppd.
H—	**Dual-Axis Drive Corrector, Model 46**—Attaches in 2 minutes to Meade Models 2080, 2080C or 2120. No drilling required. Includes R.A. drive corrector, Dec. motor and clutch system, joystick controller. Operates from 115v. /60Hz or 12v.D.C.	219.50 ppd.
I—	**Solar Filters**—Optical glass, Inconel-coated, for professional-level solar observation. For Meade 2080 or Celestron 8.	
	#955: 8″ Full-Aperture Solar Filter	165.00 ppd.
	#956: 3″ Off-Axis Solar Filter	90.00 ppd.
J—	**Series 6 Drop-In Filters** (not shown). Optical glass. Includes Pink, Yellow, Yellow-Green, Red, Blue, Neutral (0.6). Set of 6 filters	35.00 ppd.

For Nebular Filters, Thread-In Filters, Drive Correctors, Barlow Lenses, Illuminated Reticle Eyepieces, and Erecting Prisms, see the accessories listing on the facing page. These accessories are fully compatible with Meade and Celestron Schmidt-Cassegrains.

FREE Dual-Axis Drive Corrector or Optical Glass Solar Filter with Meade 8″ and 10″ Schmidt-Cassegrains!

An incredible pre-Christmas special offer to customers of Crown Optics.

Now, for a limited time, order the Meade Model 2080 8″ Schmidt-Cassegrain—the telescope that is revolutionizing modern amateur astronomy and astrophotography — at the regular Crown superdiscount price of $739.95 and receive the **Meade #955 Full-Aperture Optical Glass Solar Filter** absolutely **free** with your order. The #955 Filter permits completely safe high-resolution solar observations and photography through the Model 2080, and sells separately for $165.

Or, order the Meade Model 2120 10″ Schmidt-Cassegrain—the finest large-aperture Schmidt-Cassegrain ever offered the serious amateur — at the regular Crown superdiscount price of $1779, and we'll ship the **Meade Model 46 Dual-Axis Drive Corrector** absolutely **free** with your order. The Model 46 Drive Corrector attaches directly to the Model 2120 telescope, and permits precise electronic corrections in R.A. and Dec. simultaneously. Purchased separately, the Model 46 sells for $219.50.

Orders to receive free accessory systems must mention this ad to qualify. This offer expires December 31, 1982.

PRICE LIST

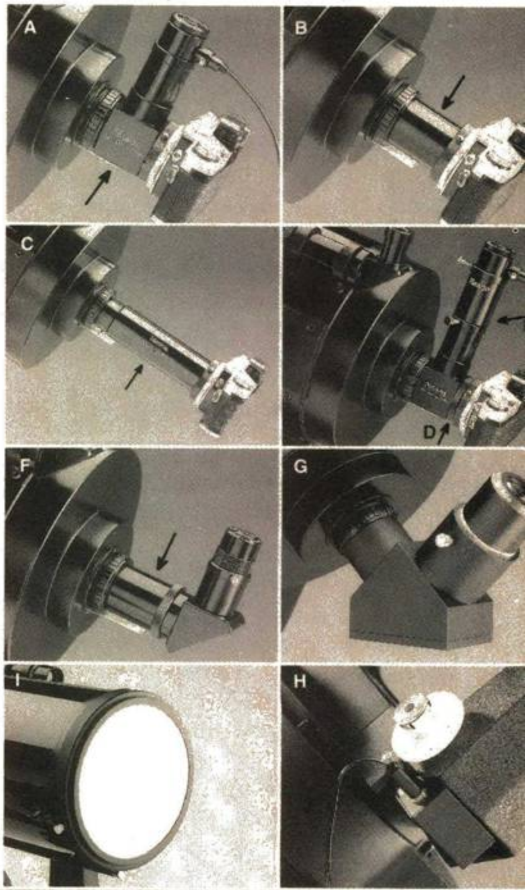
MEADE MODEL 2080: 8″ SCHMIDT-CASSEGRAIN TELESCOPE	Base price, complete	$ 739.95
MEADE MODEL 2080C: 8″ SCHMIDT-CASSEGRAIN TELESCOPE	Base price, complete	699.95
MEADE MODEL 2120: 10″ SCHMIDT-CASSEGRAIN TELESCOPE	Base price, complete	1779.00
Meade Equatorial Wedge for 2080/2080C		50.00
Meade Equatorial Wedge for 2120		80.00
Meade Variable-Height Field Tripod for 2080/2080C/2120		135.00
Meade High Transmission Coating for 2080/2080C		70.00
Meade High Transmission Coating for 2120		110.00

All prices include packing. F.O.B. Costa Mesa, Calif.

Send for your free copy of "A Frank Technical Comparison of Commercially Available Schmidt-Cassegrains."

COMPLETE GENERAL CATALOG/ASTROPHOTO BROCHURE #82-W—$3.00
(CATALOG & BROCHURE FREE WITH ANY ORDER)

We offer **ALL** *Meade products at superdiscount prices. Write us for your copy of the Meade 52-page General Catalog; we'll send it with the Crown* **SUPERDISCOUNT PRICE LIST,** *and we'll include the Meade Schmidt-Cassegrain Astrophoto Brochure at no additional charge. Catalog is $3.00 in the U.S.A and Canada by First Class Mail. (Catalog and Astrophoto Brochure sent* **free** *with any order.)*



Toll-Free Phone-Order Desk for VISA and Master Card Holders or for C.O.D. Orders, dial

800-854-7485 (orders only)

from anywhere in the continental U.S.A., except California. Order Desk Hours: 8:30 - 5:00 Pacific Time Monday through Friday

For General Information, or to place orders from all other geographical areas, dial direct (not collect): **714-966-1200.**

ORDERING INFORMATION

1. **Mail and Phone Orders only!** No dealer sales.
2. **Payment.** Personal or bank check, money order, VISA, or Master Card. (Immediate shipment on complete telescopes requires payment by cashier's check, M.O., or credit card.)
3. **All orders** are financially guaranteed by Meade Instruments Corporation.
4. **All products** are brand-new (no "seconds"!) and are normally available for immediate shipment.
5. **Within the U.S.A.:** Shipment by United Parcel Service direct to your door, fully insured, safe arrival guaranteed. **Canadian Orders:** See our Order Form for further details.
6. **All products** carry the Meade Instruments Full-Year Limited Warranty, and are backed by the Crown Optics reputation for trust and fair-dealing with our customers.
7. **California residents:** Add 6% Sales Tax.
8. **Outside North America:** Contact your Meade Instruments international distributor, or write directly to Meade Instruments Corporation for ordering information.

CROWNOPTICS, INC.
P.O. Box 8672, Newport Beach, Calif. 92660

Authorized Meade Dealer

My free discount price list saves you money!

Celestron C-8, $750, frt. paid.

Let me prove it! Send for my *free* discount price list and information sheet on how to pick the right telescope. It lists more than 80 telescopes and 500 accessories from **Celestron** (like a C-8 for $750), **Meade**, **Edmund** (like an Astroscan for $189.95), **Questar**, **Unitron**, **TeleVue**, **Lumicon**, **Accu-track**, **Brandon**, **University**, **Daystar**, **Vivitar**, **Olympus** (like an OM-1 astrocamera for $239.95), *and others!* Or send $1.00 (refunded with order) for information-packed catalogs, sheets on how to pick the right accessories, *and much more!*

Ad•Libs Astronomics
2140 Melrose Court, Norman OK 73069
(405) 364-0858
Now in our fourth year of saving you money!

SAVE $5 on HOLIDAY GIFT ORDERS with this SPECIAL OFFER

ORDER $35.00 OR MORE WORTH OF ASTROMEDIA PRODUCTS AND DEDUCT $5.00 FROM YOUR ORDER!

Use the AstroMedia order form bound into this magazine.

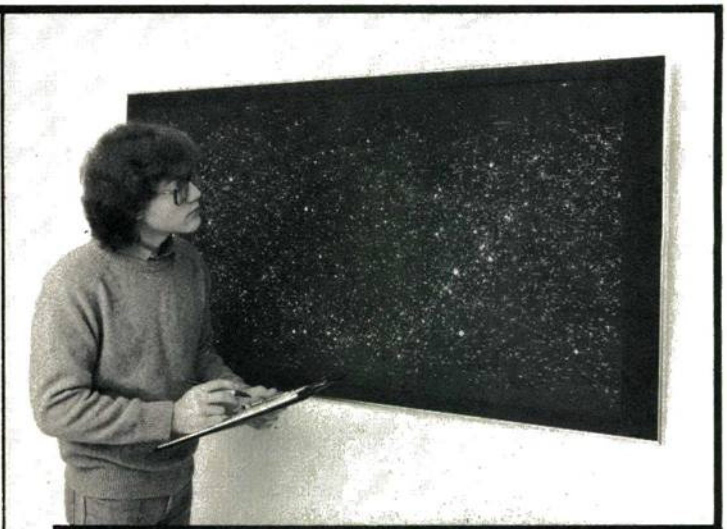
ONLY ASTROMEDIA PRODUCTS ADVERTISED IN THIS ISSUE ARE ELIGIBLE. They include: books, calendar, globes, star map, binoculars and more!

TO QUALIFY, YOUR ASTROMEDIA ORDER MUST TOTAL AT LEAST $35.00

Subscription orders are not eligible.

$5 **—Offer valid through Nov. 30, 1982 —** **$5**

Bring the Entire Night Sky into Your Home



Nearly 6,000 stars — every star visible to the naked eye — are plotted on **The Star Map**'s 30 x 60 inch black diazo surface. Each star is scaled in size to indicate its apparent brightness — so they appear just as they do in the night sky. And all major stars and constellations are labeled for easy reference.

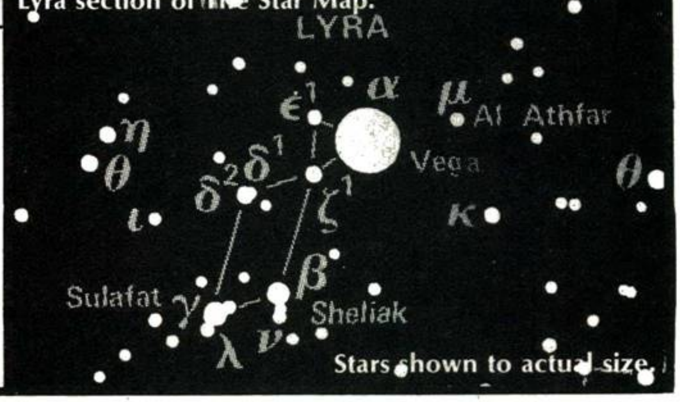
The Star Map — A functional and attractive tool for the beginning or the veteran stargazer.

$12.95

Shipped in a sturdy tube

To order, use the AstroMedia order form bound into this issue or send to AstroMedia Corp., Order Dept., P.O. 92788, Milwaukee, WI 53202.

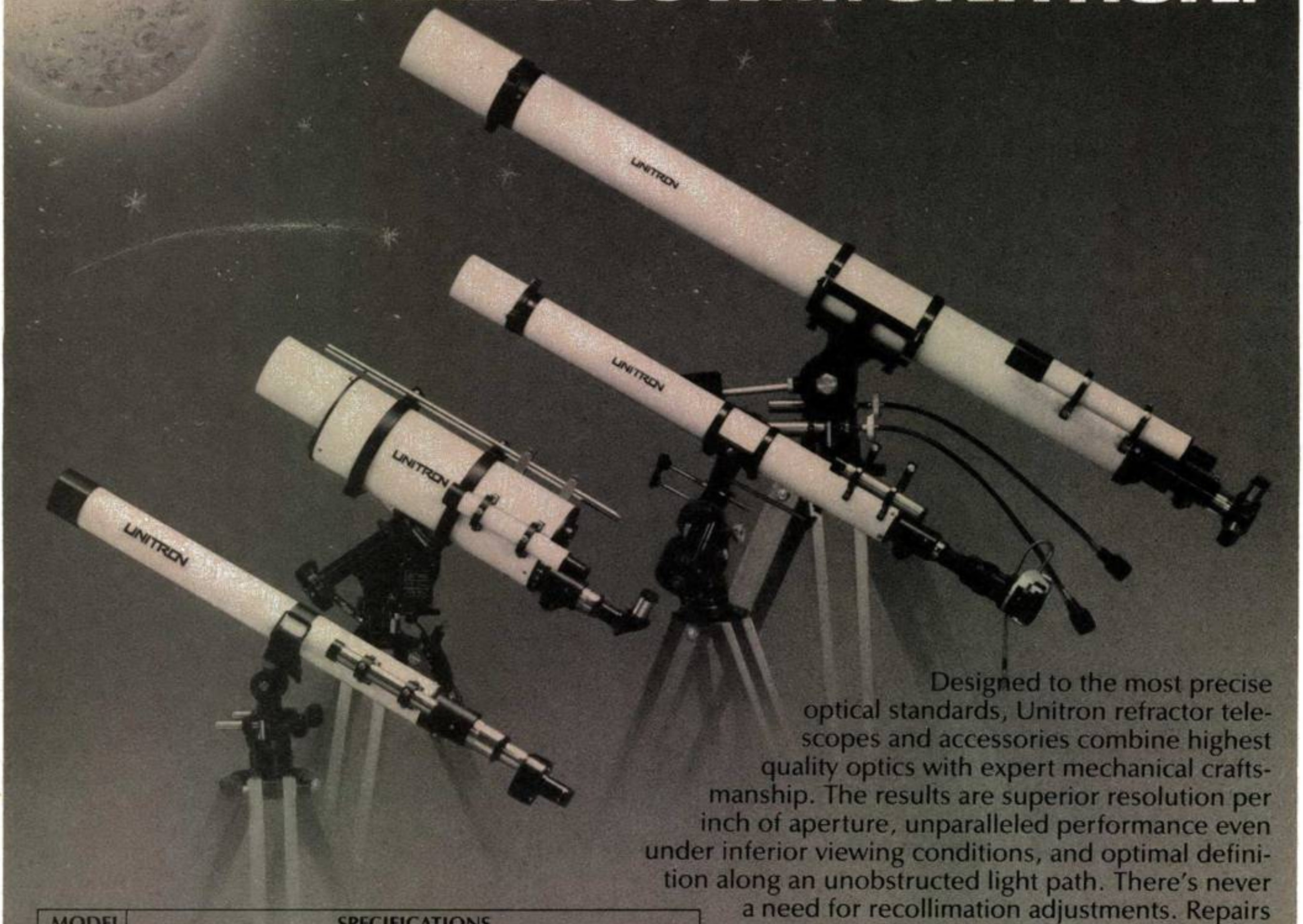
Star Map copyright © David W. Teske, 1979. All rights reserved.



Lyra section of The Star Map.

Stars shown to actual size.

Travel through the universe with UNITRON.



Designed to the most precise optical standards, Unitron refractor telescopes and accessories combine highest quality optics with expert mechanical craftsmanship. The results are superior resolution per inch of aperture, unparalleled performance even under inferior viewing conditions, and optimal definition along an unobstructed light path. There's never a need for recollimation adjustments. Repairs and maintenance are absolutely minimal and all of Unitron's telescopes are backed by a full five year warranty.

From the 2-inch Altazimuth to the 3-inch Compact Equatorial to the 4-inch Equatorial, Unitron has the right refractor for the hobbyist... or sophisticated astronomer. To learn more, send us the coupon for our complete catalog describing the full line of Unitron astronomical refractors, terrestrial spotting scopes and accessories.

MODEL	SPECIFICATIONS						
	Standard Eye-pieces	Objective Field of View	Objective Aperture (2-element, air-spaced, coated, achromatic)	Viewfinder (Focusable crossline eyepiece)	Length	Height	Weight
#105 2" Altazimuth	28X, 78X	7°12'	50 mm, f/14	4X—19 mm, 7°12' field	26 in.	54 in.	9 lb.
#114 2.4" Altazimuth	35X, 50X, 72X, 100X	7°12'	60 mm, f/15	6X—24 mm, 6°22' field	34½ in.	58 in.	16 lb.
#128 2.4" Equatorial	35X, 50X, 72X, 100X, 129X	7°12'	60 mm, f/15	6X—24 mm, 6°22' field	34½ in.	60 in.	24 lb.
#140 3" Altazimuth	48X, 67X, 96X, 131X, 171X	4°20'	75 mm, f/16	8X—30 mm, 4°22' field	47 in.	59 in.	23 lb.
#142 3" Equatorial	48X, 67X, 96X, 131X, 200X	4°20'	75 mm, f/16	8X—30 mm, 4°22' field	47 in.	59 in.	46 lb.
#131-C 3" Compact Equatorial	48X, 67X, 96X, 131X, 171X, 200X	4°20'	75 mm, f/16	8X—30 mm, 4°22' field	19 in.	60 in.	32 lb.
#150 4" Altazimuth	60X, 83X, 120X, 167X, 214X, 250X	3°22'	100mm, f/15	10X—40 mm, 2°54' field	63 in.	64 in.	50 lb.
#152 4" Equatorial	38X, 60X, 83X, 120X, 167X, 214X, 250X	3°22'	100 mm, f/15	10X—40 mm, 2°54' field	63 in.	66 in.	100 lb.

Optional eyepieces and 2X Barlow lens extend magnification range. Send for Unitron's catalog for complete specifications.
Specifications subject to change without prior notice.

UNITRON
EXCELLENCE BY DESIGN

UNITRON INSTRUMENTS, INC.
175 Express Street,
Plainview, N.Y. 11803, U.S.A.
Sub. of T.H.E. Unitron Co., Inc.

Please send me Unitron's telescope and spotting scope catalog. I enclose $1.00 for postage.

UNITRON INSTRUMENTS, INC.
175 Express Street,
Plainview, N.Y. 11803, U.S.A.
Tel. (516) 822-4601

A-11/82

Name____________________

Address____________________

City__________ State__________ Zip__________

Infrared Orion Nebula

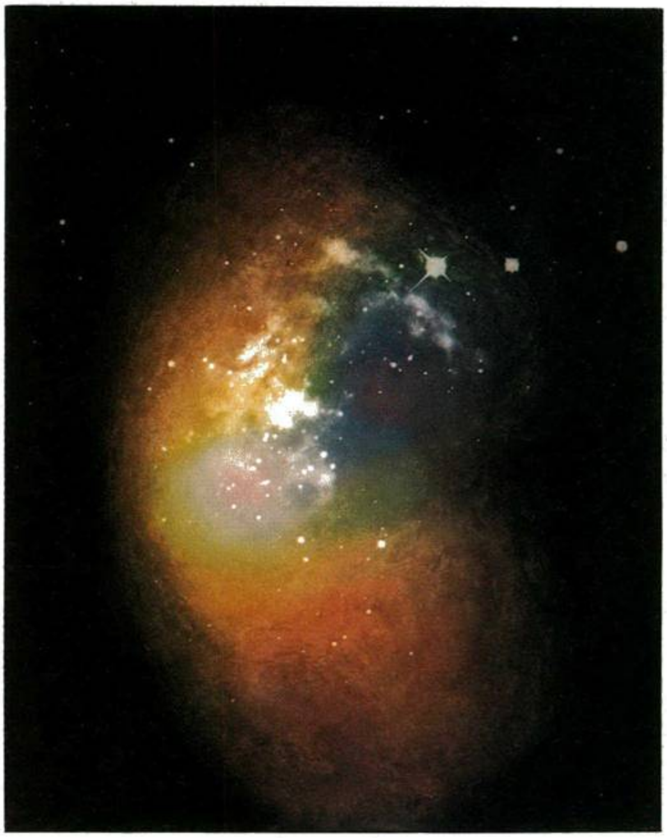
A new map shows how the Orion Nebula appears through a large infrared telescope. Astronomers superimposed the false-color infrared image on a black-and-white photograph to show that stars which formed only 100,000 years ago, are located at the peak of infrared emission, in the central region of the dense cloud of dust and gas.

The newly-formed stars appear as a bright spot to the upper left of the small cluster of stars visible near the center of the image. This cluster, called the Trapezium cluster, heats and excites the gas in the rest of the nebula.

The young stars, which are hidden by the intervening dust and gas, formed when a portion of the cloud collapsed under its own gravity. We see them in the infrared because they heat the enshrouding dust which then reradiates their energy as infrared or heat radiation.

Recent observations at infrared and radio wavelengths show the cluster is in a state of violent motion, stirred by the tremendous energy from the recently-formed stars.

This motion will eventually lead to the dissipation of the cloud many years in the future. The stars will then become visible, joining the Trapezium group to blaze brightly.



A color infrared image of the Orion Nebula superimposed on a black-and-white photo. NASA photo.

The ESA Science Program

NASA's plans for a cooperative mission with the European Space Agency (ESA) to comets Halley and Tempel-2 died for lack of money late in 1979. The following July, ESA decided to send its own craft, Giotto, to Halley. This will be ESA's first mission beyond Earth orbit, and it will conduct only the basic experiments needed to understand a comet.

In the fall of 1980, some American scientists began pushing for NASA's own Halley probe. The project failed to win approval for several reasons, one of which was Giotto. The NASA probe would have studied Halley in more detail than the European probe, but many people felt the $250 million price tag was too high.

ESA's science program has received little public attention in the U.S. While its satellites have matched similarly priced American craft in sophistication, the missions have been low-cost affairs that lacked broad popular appeal. Now the Europeans plan to tackle more ambitious projects, and many of their proposals compete with NASA's plans.

Europe's program won't challenge America's overall dominance in space science. Although ESA is a co-operative effort of 11 nations, its budget is only a tenth of NASA's. ESA spends most of its money developing the Ariane booster and the Spacelab laboratory for the space shuttle. Scientific research gets only 16% of the budget — $127 million this year. The United States, by comparison, will spend $568 million on its space science program this year.

ESA's Director General acknowledges that the current funding doesn't give European researchers the opportunities they need to remain at the forefront of space science. He's pushing to expand the science program over the next decade.

In the meantime ESA does the best it can. Expensive projects, like NASA's Space Telescope or Galileo Jupiter orbiter, are beyond its means. The European agency frequently got around the tight budget by working with NASA. Ten percent of the Space Telescope's funding, for example, comes from ESA in return for observing time.

But now the Europeans are wary of future cooperation with the United States. Last year, budget cuts forced NASA to cancel the joint U.S.-European Solar Polar mission. ESA was left paying for its portion of a mission that no longer had the same scientific value.

When ESA managers select their next science mission late this year, they'll choose one from five or six all-European proposals. The Europeans and Americans had been looking into a joint lunar project, but ESA canceled that study after NASA dropped its Solar Polar spacecraft. A look at the European proposals gives a good idea of what ESA can do:

DISCO — Most of our understanding of the Sun's interior comes not from examining that body, but from our general theories of stellar evolution. DISCO's high precision spectrophotometer would study the oscillations of our star's surface. The measurements would reveal both the structure of the inner Sun and how the different layers rotate. The results could either strengthen astrophysicists' theories about stellar evolution or force them to develop new ones.

Another set of instruments would study the solar wind. Combined with data from ESA's Solar Polar craft, DISCO would provide researchers with the first three-dimensional picture of the Sun's magnetosphere.

KEPLER — The American and Soviet missions to Mars have concentrated on taking pictures and looking for life. If approved, Kepler would orbit the Red Planet for two years studying its geophysical characteristics and answering these questions: What is the structure of the planet's interior? How does that structure relate to the surface terrain? What forces control the weather? Does Mars have a magnetic field? What are the characteristics of the upper atmosphere and ionosphere? How does the planet interact with the solar wind? NASA's Pioneer Venus craft studies similar questions at Venus.

POLO — The Apollo Moon landings returned volumes of information on a handful of lunar sites, but geologists now need an advanced polar lunar orbiter to study the Moon's surface chemistry and interior structure. Then they could apply the knowledge gained from Apollo to the whole Moon.

In the late 1970s, NASA tried unsuccessfully to get funds for such a mission. Then ESA began looking at a similar project as a cooperative mission with NASA. When the U.S. canceled its Solar Polar craft, the Europeans ended the study. They couldn't afford the mission on their own, and NASA proved itself an unreliable partner. But early this year a consortium of German institutions offered to bear some of the cost. ESA has restarted its study, although they may not complete it in time for this mission selection. If not, the project will be considered for the next selection.

ISO — The Earth's atmosphere prevents most wavelengths of infrared light from reaching the ground. Late this year the Infrared Astronomy Satellite will perform the first astronomical

ME COLD? NEVER!

There are some people who love the cold and the wind—but I'm certainly not one of them. I used to try just about everything to stay warm—big coats, bulky sweaters, thermal underwear, the works. Somehow I still was cold or worse yet, sweating under layers of heavy clothing.

Then a friend told me about Damart Thermolactyl and I haven't been cold since! Indoors or out, this super-soft and lightweight underwear is a real miracle, as far as I'm concerned. In fact, you can turn your thermostat into the 60's without sacrificing any comfort.

The secret is the fabric. It retains and reflects my own natural body warmth. And it's knitted to let perspiration out! You stay warm and dry, no matter what the temperature.

I'm convinced Damart is the best cold weather wear there is. So are Mt. Everest climbing expeditions. Damart is also worn by the Pittsburgh Steelers, Buffalo Bills, New York Jets and Philadelphia Eagles Football Clubs.

There's an exciting free color catalog that tells the full Damart Thermolactyl story and displays the whole Damart line for men and women, *including tall sizes*. Send for your FREE copy now!

THE PROOF IS IN THE WEARING!

LIMITED WARRANTY TO CONSUMERS ★ Good Housekeeping PROMISES REPLACEMENT OR REFUND IF DEFECTIVE

Damart
Thermolactyl

DAMART THERMOLACTYL
1982-1983 edition

WHEN IN THE BOSTON AREA,
VISIT OUR PORTSMOUTH, N.H.
STORE (603) 431-4700

THERE IS NO WARMER UNDERWEAR MADE!
Fill out and send to:

DAMART, DEPT. 10342
1811 Woodbury Ave.
Portsmouth, N.H. 03805

YES! Rush me your **FREE DAMART** Catalog . . . I want to enjoy the fantastic warmth of Thermolactyl Underwear, a DAMART® exclusive. (I understand there is no obligation.)

PRINT NAME

ADDRESS

CITY STATE ZIP

© 1982, Damart, Inc.

infrared survey from above the Earth's atmosphere. The information returned might spark the same kind of revolution in astronomy that the first radio telescopes and X-ray satellites did.

ESA's proposed Infrared Space Observatory would follow up on IRAS's studies, and carry a more sophisticated instrument payload — an infrared camera, two Michelson interferometers, and broadband photometers where IRAS carries just photometers and a low sensitivity spectrometer. ISO would operate as an observatory; astronomers could request time on it to carry out their research. The studies could range from observing star formation in other galaxies, to mapping dust and gas clouds in our own galaxy, to measuring the composition of asteroids.

MAGELLAN — The Magellan satellite would carry a high resolution spectrometer to explore the far ultraviolet portion of the spectrum. Like ISO, this would be an observatory. Astronomers could request them for observations ranging from interstellar gas clouds, to regions of star formation, to the remnants of supernovae.

X-80 — X-ray astronomy has become one of the most fruitful branches of astronomy, a window into the more violent processes in the universe, where matter is subjected to extreme density, temperature, and magnetic fields. Astronomers have been surprised to learn how variable X-ray sources are, both in their output of energy and in their spectra. ESA's proposed Timing and Transient mission would carry four instruments to measure this variability. From this mission would come a basic understanding of what causes X-ray emitters to vary their output so much.

With the exception of DISCO, all of these missions have NASA-designed counterparts. In some cases the two agencies are considering nearly identical projects. ESA's plans for a lunar orbiter, for example, nearly duplicate the mission NASA proposes. In other cases, the two agencies are considering complementary plans. ESA's infrared telescope would be a valuable precursor to the larger infrared telescope that NASA wants to build for use with space shuttle.

Van R. Kane.

New National Space Policy

On July 4, President Ronald Reagan announced a national space policy that sets the direction of U.S. space efforts for the next decade. The policy is the result of an interagency review requested by Reagan in August 1981. The review included a comprehensive analysis of all segments of the national space program, but its primary objective was to provide a framework for a farsighted space program.

The administration's goals are to:

— strengthen the security of the United States.

— maintain the space leadership of the United States.

— obtain economic and scientific benefits through the exploitation of space.

— expand investment and involvement in space-related activities by the private sector.

The new directive also calls for the continued support of international cooperative activities and maintenance of the freedom of space. The United States is committed to space exploration by all nations for peaceful purposes. "Peaceful purposes" include activities that concern national security.

The policy statement points out that the space systems of any nation are national property. Purposeful interference with space systems will be viewed as an infringement upon sovereign rights.

The Reagan space policy encourages domestic commercial exploitation of space. Such activities must be consistent with national security concerns, treaties, and international agreements. In addition, the U.S. supports international cooperative space-related activities to achieve scientific, political, economic, or national security goals.

The overall space program will

Two New Sungrazers

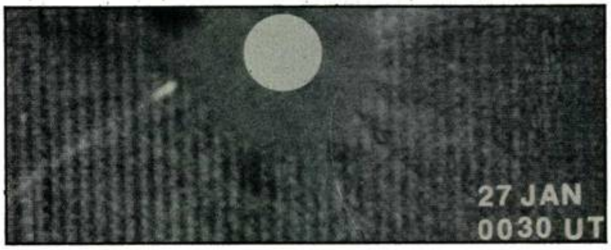
Scientists at the Naval Research Laboratory report the discovery on photographic plates taken in 1979 of two new comets which hit the Sun.

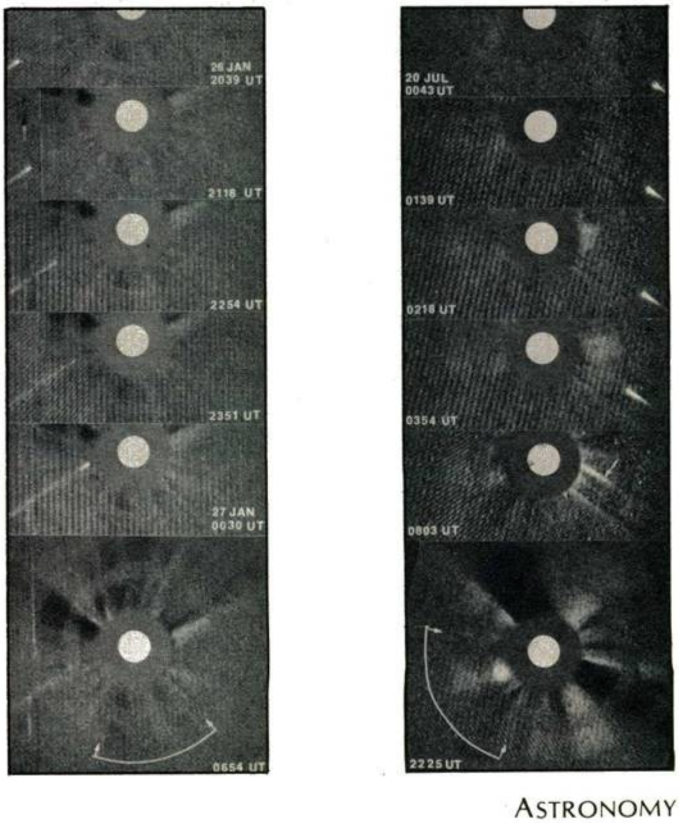
The comets were uncovered during routine data processing of images from NRL's SOLWIND satellite coronagraph experiment. NRL researchers reported the fiery collision of the first sungrazer earlier this year. (See AstroNews, January 1982, p. 64.)

Astronomers once thought sungrazers were rare, but these newly discovered comets bring the total to three found in the first 2½ years of data collecting by SOLWIND. Only nine had been found in the preceeding 300 years. These sightings indicate that small sungrazers, which are difficult to observe from the ground, may be common.

The newly-discovered comets followed normal orbits, except that they never reappeared after passing around the Sun. NASA scientists theorize that their orbits' distance from the Sun at perihelion (the closest point to the Sun) was so small that the comets were vaporized by intense solar radiation.

If small comets frequently pepper the Sun, scientists may have a new class of cometary bodies to observe during future space missions. Earth-orbiting instruments could determine the chemical composition and physical state of these small bodies as they burn up in the solar atmosphere. Comets, especially their innermost cores, may represent the original material that went into the formation of the planets.





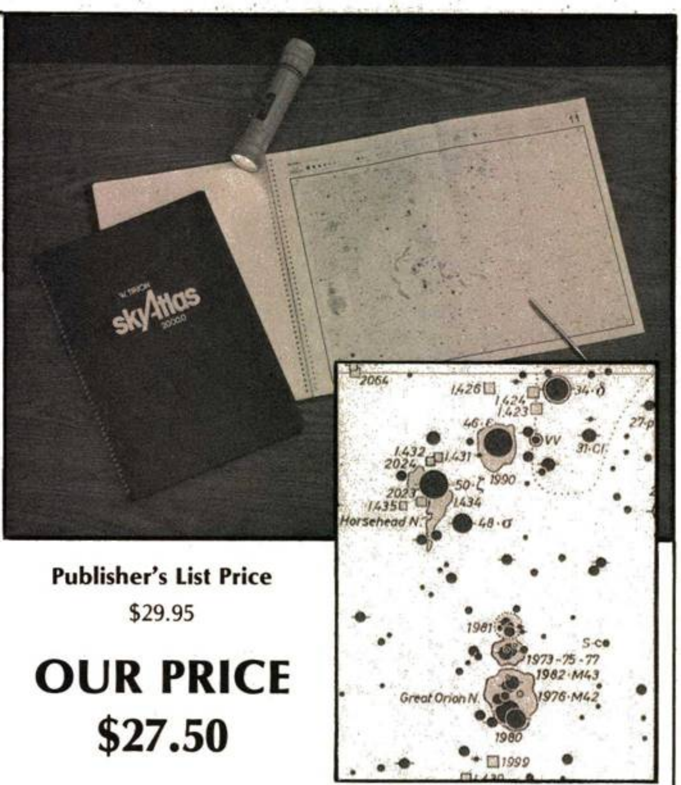
These sequences show two sungrazing comets that vaporized in January and July 1981. NRL photos.

Sky Atlas 2000.0

Join the ranks of knowledgeable amateur astronomers with the **Sky Atlas 2000.0**. Find your way to galaxies, star clusters, and nebulae with ease. These giant star maps are crisp and distinct — and they're beautifully illustrated in color. Even the arm-chair astronomer will enjoy tracking down favorite nebulae and galaxies and other celestial objects seen in ASTRONOMY.

- 26 charts encompassing both hemispheres
- Each jumbo chart 12½" x 17½"
- 43,000 stars — to the 8th magnitude
- 2,500 color-coded deep-sky objects
- Clearly-defined constellation boundaries
- All Messier objects and thousands of NGC objects
- Celestial coordinates for the year 2000
- Handy reference key on each chart

Also available: **Sky Catalogue 2000.0.** 632 pages of information on over 45,000 stars — including positions, spectral type, and distance. Paperback, $27.50.


W. TIRION
skyAtlas
2000.0
2064
1426
1424
1423
34·δ
46·ε
VV
31·Cl
27·p
1432
2024
1431
1990
50·ζ
2023
1435
1434
Horsehead N.
48·σ
1981
S·c
1973-75-77
1982·M43
Great Orion N.
1976·M42
1980
1999

Publisher's List Price

$29.95

OUR PRICE

$27.50

U.S. Postage included — Foreign add $2.00

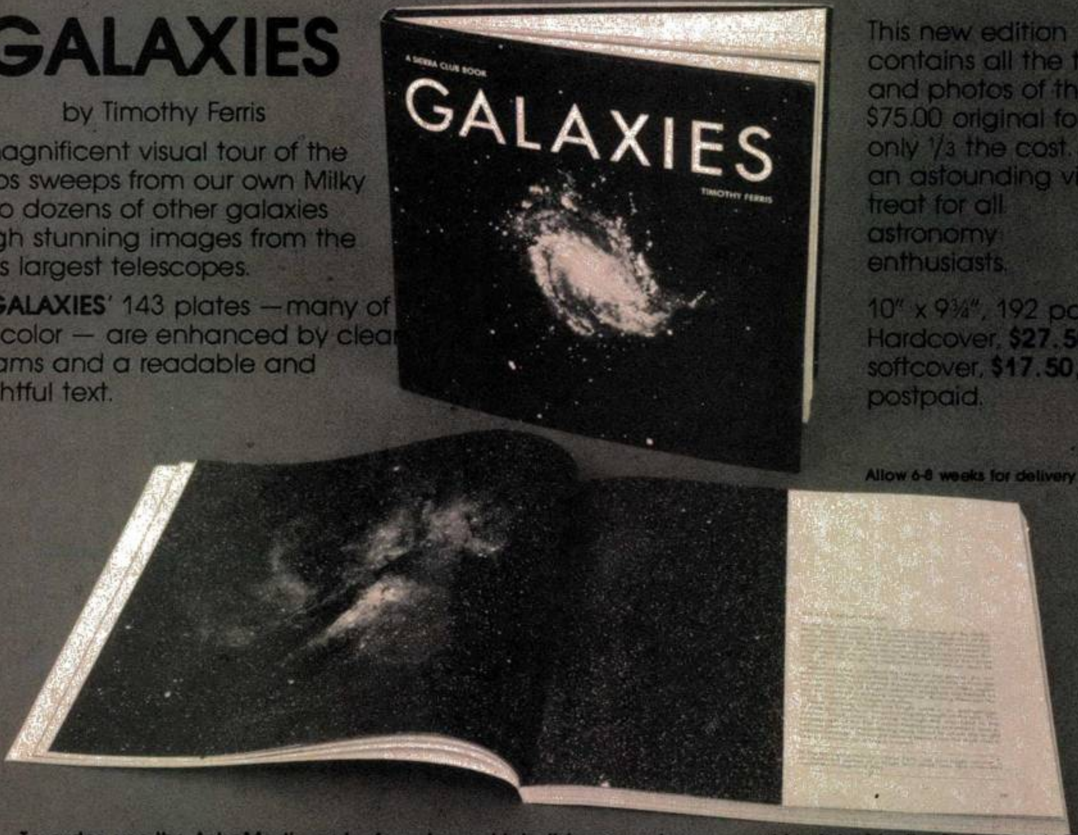
To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

GALAXIES

by Timothy Ferris

This magnificent visual tour of the cosmos sweeps from our own Milky Way to dozens of other galaxies through stunning images from the world's largest telescopes.

And **GALAXIES**' 143 plates — many of them color — are enhanced by clear diagrams and a readable and thoughtful text.


A SIERRA CLUB BOOK
GALAXIES
TIMOTHY FERRIS

This new edition contains all the text and photos of the $75.00 original for only ⅓ the cost. It is an astounding visual treat for all astronomy enthusiasts.

10" x 9¾", 192 pages. Hardcover, **$27.50;** softcover, **$17.50,** postpaid.

Allow 6-8 weeks for delivery

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202

ASTRONEWS

be comprised of two separate but strongly interacting programs — national security, run by the Department of Defense, and civil, run by NASA. The Space Transportation System (STS) will continue as the primary launch system for both national security and civil government missions. Launch priority will be given to national security missions. Operational responsibility will remain with NASA for control of civil missions, and with the DoD for national security missions.

Civil programs will continue to balance research and development operations and exploration for science applications and technology. The key objectives of the civil programs are: to preserve the preeminence of the United States in critical space activities; to enable continued exploitation and exploration of space; to conduct research and experimentation of astrophysical phenomena and the origin and evolution of the universe, as well as the continued monitoring of the Earth and its environment.

National security space programs will support such functions as command and control, communications, navigation, environmental monitoring, warning, and surveillance for space defense — including the development of an anti-satellite (ASAT) capability, with operational deployment as a goal.

The national security and civil space programs will be closely coordinated and will emphasize technology sharing within necessary security constraints.

The Reagan policy statement has received much criticism since its release, largely for what it does *not* say. The House Science and Technology Committee's space subcommittee called Reagan's policy "too vague, too militarily oriented, and a policy that squanders the current and future capability of the U.S. space program."

One of the chief complaints centers around the apparent lack of committment to study the construction of a permanent space station. However, even though Reagan didn't come right out and oppose such a station, proponents felt his endorsement was not strong enough.

NASA adminstrator James M. Beggs defended the policy and said that it certainly does not rule out major new initiatives such as the development of a space operations center. Beggs lobbied hard for the President to make a more forceful committment to the operations center and to the Orbiter fleet. Funding for the fifth Shuttle craft is still a matter of much dispute, and outgoing Johnson Space Center Director Chris Kraft, Jr. said that the current fleet of four orbiters is "probably only half enough."

Leonids Hyperactive in 1998-1999?

Each year around mid-November, the Leonid meteor shower occurs — with an average rate of a dozen meteors an hour. But sometimes this relatively insignificant shower is spectacular: Leonid loyalists observing before dawn on November 17, 1966 witnessed an incredible display, estimated at 150,000 meteors an hour — about 40 per second!

What causes such displays? The dust particles that make up the Leonid meteor stream come from Comet Tempel-Tuttle — a periodic comet that orbits the Sun once every 33.25 years. Its last perihelion passage occurred in 1965 and it should return in 1998.

Writing in a recent issue of *Icarus*, D.K. Yeomans of the Jet Propulsion Laboratory reports that significant meteor showers have usually occurred every 33 or 34 years since as far back as 902 A.D. Some of these displays have been intense: 1833, 50,000 meteors/hour; 1867, 5,000/hour; 1901, 144,000/hour; 1966, 150,000/hour.

Yeomans computed the comet's orbit and examined meteor reports from American, Chinese, European, Japanese, and Korean sources. He then investigated the distribution of dust scattered along the orbital path of the comet and found that particles traveling inside the comet's orbit often produce large fireballs, which were seen in 1498, 1601, and 1602.

Yeomans also reports that solar radiation pressure and planetary perturbations push most of the small particles of cometary dust behind the comet, toward the outside of the orbit. Thus when the Earth passes behind and outside the comet's path, the chances are very good for a spectacular meteor display. The Earth passed through this region in 1833, 1867, 1901, and 1966.

But exceptions occur. In 1932, the Earth again ran through a cloud of such particles, yet the Leonids produced only 240 meteors an hour — good, but not spectacular. Yeomans feels this unreliability shows that dust is not scattered evenly around the comet but tends to travel in clumps.

Keeping this caution in mind, he suggests that in 1998 and 1999 "conditions will be optimum" for a very fine Leonid display, since the Earth will again pass behind the comet and outside its orbit. But because of the non-uniform distribution of dust, he cannot make a firm conclusion. Yeomans says, "The likelihood of an unusual Leonid shower event in 1998 and 1999 is very good, but by no means certain." *Ken Croswell.*

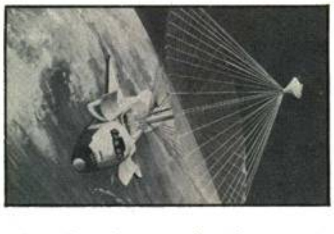
Orbiting VLBI

A proposed Very Long Baseline Interferometer (VLBI) system could link an orbiting radio astronomy antenna to one or more antennas on Earth in a way that would provide highly detailed coverage of the universe, according to NASA.

In the past, ground-based radio telescopes have helped astronomers discover and identify pulsars, quasars and other galactic phenomena. A space-based VLBI system could deliver similar intriguing results.

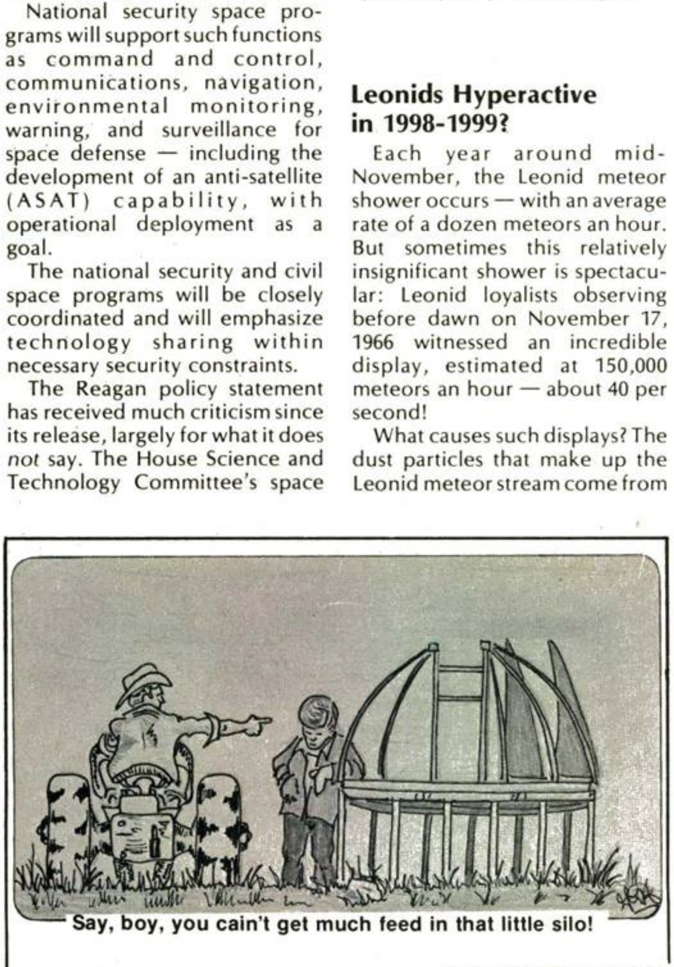
A long baseline interferometer is a system of antennas placed thousands of miles apart that simultaneously study radio frequencies emanating from the heavens. This linkage of antennas gives high-resolution images of celestial sources that can't be acquired with a single, independent antenna. The signals received by each antenna in an interferometer system are recorded and synchronized by extremely accurate atomic clocks. These signals are later assimilated to produce radio images of the celestial sources.

The longer the distances, or baselines, between the antennas, the larger the effective telescope diameter. Two radio telescopes, placed a thousand miles apart, make a radio antenna "dish" one thousand miles across. The longest baseline on Earth is 6,600 miles with interferometer antennas in California and Australia. A scope with a baseline that extends far into space should have greatly improved resolution.


NASA artwork.

Space is the only answer to achieving the ultimate potential of radio astronomy because the maximum baseline length has been reached on Earth. Ground-based interferometers have been in use for years and have given astronomers new insight into our universe.

Quasars, enormously powerful objects far out in space, are one example. According to Einstein's special theory of relativity, the speed of light is the ultimate speed. But Earth-bound interferometers suggest components of *some* quasars split off from the main bodies at velocities that exceed the speed of light. This is the kind of puzzle that makes astronomers want to


Say, boy, you cain't get much feed in that little silo!

Cartoon by Gary Hertzler

ASTRONOMY Observer's Page

OBSERVE THE NIGHT SKIES WITH BUSHNELL BINOCULARS

7x35 Sportview®
The all-around glass — light, sturdy and portable. 5mm exit pupil, 37.5 Relative Light Efficiency, 2-year warranty.

$51.95 (Orig. $66.95)

7x50 Sportview®
High light-gathering ability makes this excellent for astronomy, but still small and light enough for general use. 7.1mm exit pupil, 76.5 RLE, 2-year warranty.

$64.95 (Orig. $86.95)

10x50 Explorer®II
The ultimate for astronomy, designed for tripod use under low-light conditions. 5mm exit pupil, 37.5 RLE, 20-year warranty.

$169.95 (Orig. $194.95)

Philips'
PLANISPHERE
showing the principal stars visible for every hour in the year
For Latitude 42°N
Useful in Middle Latitudes
PLANISPHERE

FIND THE CONSTELLATIONS WITH A PLANISPHERE

What time does Leo rise in mid-January? When will the Pleiades set in early May? This easy-to-use device shows "what's up" at any time, on any date.

The 10" diameter size is available in 3 latitudes: 52°, 42°, and 32°. The 5" pocket-size model is available in 42° and 32° ranges only.

Both are waterproof plastic; please specify latitude.

10" Planisphere $7.95
5" Planisphere $4.50

OBSERVER'S BOOKSHELF

Burnham's Celestial Handbook: Burnham. The great modern classic about deep-sky objects; arranged by constellation, it covers the whole sky in 3 volumes. 2138 pages in all, paperback
Vol. 1 — $9.50
Vols.2 & 3 — $10.50 each.

The Messier Album: Mallas & Kreimer. An observer's guidebook to the whole Messier catalog — a finder chart, visual sketch and description, and a photo on each. 248 pg, hardcover, **$14.50.**

Astronomy with Binoculars: Muirden. The classic guide to sky-watching with the simplest equipment. Includes how to buy a good pair of binoculars and observing projects. 156 pg, hardcover, **$13.50.**

Observational Astronomy for Amateurs, 4th ed.: Sidgwick. A collection of facts on observing techniques covering the Sun, Moon and all the planets, as well as aurorae, meteors, zodiacal light and double stars. 348 pg, paperback, **$6.50.**

Amateur Astronomer's Handbook, 4th ed.: Sidgwick. Tips on mountings and drives, eyepieces, mirror and lens testing — as well as data on human vision, the Earth's atmosphere, etc. 568 pg, paperback, **$8.50.**

ALSO AVAILABLE . . .

Sky Scanner
Nowell, P, 12 pg $4.95

Whitney's Star Finder
Whitney, P, 102 pg $9.50

Celestial Objects for Common Telescopes
Webb, P, 606 pg, ... 2 vol. set $11.00

Star Names
Allen, P, 563 pg $6.50

Sky Catalogue 2000.0
Hirshfeld & Sinnott, P, 632 pg $27.50

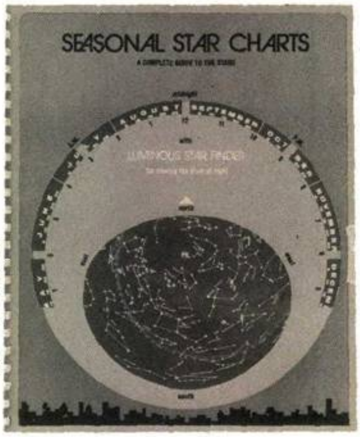
How to Build a Dobsonian Telescope
P, 52 pg $4.95

How to Build Your Own Observatory
P, 42 pg $3.95

TELESCOPE MAKING Magazine
Quarterly, 1 year $10.00

H = Hardcover, P = Paperback

SEASONAL STAR CHARTS



Guide to the heavens with 8 star maps and accompanying lists of objects in each constellation; has Star Finder planisphere on cover. Plasticized paper, ring-bound to lie flat. **$8.00**

SkyAtlas 2000.0

SKY ATLAS 2000.0

Join the ranks of knowledgeable amateur astronomers with Sky Atlas 2000.0. Find your way to galaxies, star clusters, and nebulae.

- 26 wire-bound charts each 12½"x17½"
- 43,000 stars — to the 8th magnitude
- 2,500 color-coded deep-sky objects .... and more.

Publisher's List Price $29.95
OUR PRICE $27.50
Foreign orders add $2.00

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.
All prices include postage.

ASTRO NEWS

extend the length of the interferometer baseline into space with an Earth-orbiting antenna.

One proposal is to position a large antenna interferometer in a 5,000-kilometer orbit by the late 1990s. Used with other interferometer antennas on Earth, resolution could be one milli-arc-second — the angle of view a person in Los Angeles would have of a dime held up in New York.

An additional advantage in placing an interferometer system in space would be the expansion of view such a system would allow. Antennas are generally placed on temperate-zone land masses where scientific activities are concentrated. Since most of the science interest in the world is found in the United States, Europe and Asia, which occupy the northern hemisphere, only east-west antenna separations exist. A space-based interferometer in a 5,000-kilometer orbit would overcome that problem.

The SCARAB underwater sled photographed the SRBs on the Atlantic Ocean floor. NASA photo.

Robot Sled Images SRBs

NASA officials have decided to salvage some parts of the two Solid Rocket Boosters (SRBs) which sank in the Atlantic Ocean after the launch of the fourth Space Shuttle mission on June 27, 1982.

Using remote-controlled underwater cameras, salvage teams have mapped the sites where the booster parts lie. They have determined that the boosters broke apart from the force of impact. One booster broke into many pieces; the largest is a section of the forward skirt stiffener ring with at least two parachutes attached.

The forward skirt and the top solid rocket booster segment of the other booster remain intact. This 12-meter long segment contains the flight data recorder and other electronic equipment that is of interest to the NASA board investigating the failure.

None of the hardware is reusable, but recovering the recorders and the parachute mechanisms will help pinpoint the cause of the failure. The timing of the explosive bolts that separate the SRBs from the parachutes apparently caused the malfunction.

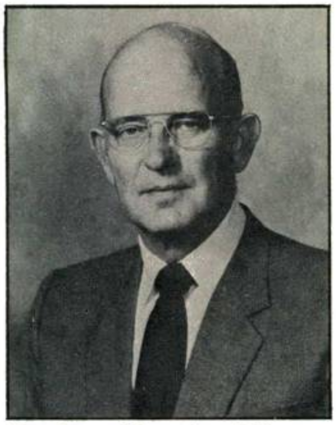
JPL's New Director

Former Air Force Chief of Staff General Lew Allen, Jr., will become the new director of the Jet Propulsion Laboratory, as well as vice-president of the California Institute of Technology, Caltech officials announced in July.

Allen, 56, replaces Bruce Murray, who stepped down after six years in the position. The Jet Propulsion Laboratory, a leading center of planetary research and development of new space technology, is administered by Caltech for NASA.

Allen's credentials as a scientist and administrator are impressive, although his military background has concerned many JPL workers. After graduating from West Point in 1946, Allen earned a Ph.D. in physics from the University of Illinois in 1954. He then spent three years at Los Alamos researching the physics of high-altitude nuclear explosions, followed by four years as science advisor to the Physics Division of the Air Force Special Weapons Laboratory. He became Air Force Chief of Staff in 1979.

Caltech president Marvin L. Goldberger admits that Allen's military background is a sensitive issue, especially since Caltech authorized JPL to pursue unclassified military contracts to fill the decline in activity left by NASA's curtailment of planetary exploration. Goldberger adds, however, "I believe he is dedicated to the civilian space program, and his interests in JPL correspond exactly to my own."



Dr. Lew Allen, Jr., JPL's new director. JPL photo.

ASTRO CALENDAR

October 9-12.	**Conference on Lunar and Planetary Volatiles** (professional meeting). Lunar and Planetary Institute, Houston, Texas. Contact: Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.
October 13-16.	**18th Conference of the Great Lakes Planetarium Association.** Lakeview Planetarium, Peoria, Illinois and I.S.U. Planetarium, Normal, Illinois. Contact: Carl J. Wenning, Department of Physics, Illinois State University, Normal, IL 61761.
October 22-24.	**Custer Institute's Astronomy Jamboree.** Contact: Tom Carey (516) 271-2032 or George Lomaga (516) 298-4857. Astronomy Jamboree, Box 1204 Main Bayview Rd., Southold, NY 11971.
November 12-14.	**Space '82 — British Interplanetary Society.** Piccadilly Hotel, London. Contact: Executive Secretary, British Interplanetary Society, 27-29 South Lambeth Road, London SW8 1SZ.
November 15-18.	**Chondrules and their Origins** (professional meeting). Lunar and Planetary Institute, Houston, Texas. Contact: Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058 or Albert King, Department of Geosciences, University of Houston, Houston, TX 77004.
April 15-18, 1983.	**National Congress of Astronomers,** Astronomical Society of Southern Africa. Contact: M. Andrew Gray, P.O. Box 118, Johannesburg 2000, Republic of South Africa. Phone 011-394941 (Office) or 011-469391 (home).

Meeting notices to appear in AstroCalendar must be submitted at least three months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

ASTROMART

AstroMart listings are free to all our readers, but we can allow only 2 per person per year. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

ANNOUNCEMENT — The National Alonomy Society has been founded to spread an interest in alonomy and astronomy. Alonomy deals with telescope polar alignment and the observation of interesting objects. Meetings are held at 2:00 p.m. on the first Saturday of each month at the address below. New members are welcome. Contact David Koller, 19 Bernard Rd., East Brunswick, NJ 08816. Phone (201) 246-3687.

ANNOUNCEMENT — Interested in Amateur Astronomy in north central Ohio? Richland Astronomy Society wants you! Present membership is 45 and we're still growing. Contact Emil Diener, 237 Oakwood Drive, Mansfield, OH 44906.

ANNOUNCEMENT — The Active Amateur Astronomers of Maryland will hold meetings on the following Wednesdays: October 20, November 17, December 15; in 1983: January 19, February 16, March 23, April 20, June 22, July 20, and August 24. Meetings are held from 7 to 9 p.m. at the Hamilton Branch of the Enoch Pratt Library on Hartford Road. Bring your scopes, as we go observing after the meeting if skies are clear. Contact Bob Calhoon, (301) 444-5668, or Doug Cook, (301) 628-7222.

ANNOUNCEMENT — Individuals in southeast Kansas interested in forming an amateur astronomers' club contact Mike Baldassaro, 1006 East Birch, Independence, KS 67301. Phone (316) 331-7335.

ANNOUNCEMENT — The Bays Mountain Amateur Astronomers meet monthly at Bays Mountain Nature Center. Lectures, observing, projects, films and other activities. A friendly group for all ages. Contact Bays Mountain Planetarium, Route 4, Kingsport, TN 37660. Phone (615) 245-4192.

ANNOUNCEMENT — The Saint Joseph County Astronomical Society, South Bend, Indiana, welcomes all persons living in the Michiana area to attend our monthly meetings and observing sessions. Write to P.O. Box 262, South Bend, IN 46624 for meeting schedule.

ANNOUNCEMENT — The Chicago Astronomical Society meets on the third Friday of each month at the Adler Planetarium. Meetings are held in the Milky Way Theater, beginning at 7 p.m. Leave a message on our answering machine at (312) 725-5618, or write to P.O. Box 48504, Chicago, IL 60648. Ask for our free brochure.

ANNOUNCEMENT — The Centre d'Etudes et de Recherches Astronomiques, a non-profit organization, is organizing a research program for detecting extragalactic supernovae. We would like to be in contact with amateurs having a telescope and some scientific background in order to set up an international network. Contact C.E.R.A., 51 Boulevard Victor Hugo, 06000 Nice, France.

ANNOUNCEMENT — For inclusion of your club or association in the worldwide International Directory of Amateur Astronomical Societies, please contact Dr. J. Manfroid, Institute of Astrophysics, avenue de Cointe 5, B-4200 Cointe-Ougree, Belgium, or Dr. A. Heck, ESA Satellite Tracking Station, Apartado 54065, Madrid, Spain.

ANNOUNCEMENT — If you live in Saginaw, Michigan or thereabouts, we want you for a member of the Celestial Skygazers astronomy club. Dues are 75 cents a month. For information send a SASE to The Celestial Skygazers, c/o Brian Burt, 4405 N. Michigan Ave., Saginaw, MI 48604.

WANTED — Minimum $14^1/_2$" or larger reflector telescope of any design. Must be complete with good working mount and excellent optics. Portability preferred. Contact Richard Chapin, 602A South Pantano Rd., Tucson, AZ 85710. Phone (602) 885-9797.

WANTED — *National Geographic* back issues: pre-1957 as well as August 1958, August 1959, July 1960, May 1961, September 1961 and November 1978. You pay postage. Contact Dave J. Ludwikoski, 2610 Lagrange St., Toledo, OH 43608.

WANTED — Small telescope for beginning astronomer. Also, back issues of ASTRONOMY. Send offers to Paul Goodson, 1808 Rosewood Dr., Greenville, NC 27834.

ADVERTISER LISTING

ADVERTISER	PAGE
Ad-Libs Astronomics	62
Astro Calendar	44
Astro Cards	72
Bernardo	72
Celestial Studios	73
Celestron International	52-53, 95, 96
Coulter Optical	23
Criterion Mfg. Co	34, 54
Crown Optics	59, 60-61
Damart	65
Dey Optics	81
Dixie Telescopes	31
Dixon Spacescape	80
Edmund Scientific	27
E&W Optical	80
Felix, Jessica	81
Haag, Robert A.	81
Hansen Planetarium	73
Hensley Productions	71
International Seminar	31
K&W Astronomics	80
Lumicon	27
MacMillan Book Club	25
Meade Instruments	2-3
Merrill Scientific	71
Omni	33
Optica b/c	81
Optron	45
Oriental Eclipse Express	81
Reich, Lawrence	73
Santini Opticians	35
Sky Log	81
Spherical Concepts	31
Star Tracker	73
Super-T	45
TeleVue	35
Texas Nautical	72
Tomlin Industries	72
Tuthill, Roger	38
Unitron	63
University Optics	72
Willmann-Bell	80

HOBBIES HOBBIES HOBBIES HOBBIES

1983 catalog, 200 pages. Thousands of chemicals, glassware, science-hobby equipment. Send $2.00. Merrell Scientific, 1665 Buffalo Road, Rochester, New York 14624

HOBBIES HOBBIES HOBBIES HOBBIES

YOUR SOLORSCAPE

Award-winning artist Greg Hensley sharpens the details of the solor system to more clearly see our space environment. Hand-printed, signed, color photos are now available by mail order. (Painting above.)

Print sizes
8×10" $15.00
11×14" $20.00
16×20" $30.00
20×24" $50.00
(add $2.00 for shipping)

To order send check or money order to:
Hensley Productions
Box 11554 • Aspen, Colorado 81612

Commemorate *Columbia's* Historic Test Flights with These Framed NASA Emblems

The U.S. Space Shuttle *Columbia* has opened a new era in American space exploration — the age of reusable launch vehicles. Each of *Columbia*'s 4 test flights is represented by the NASA emblem worn by the astronauts during their missions.

Columbia Missions
STS 1 — Young & Crippen
STS 2 — Engle & Truly
STS 3 — Lousma & Fullerton
STS 4 — Mattingly & Hartsfield

- Silver frame — 6½" x 20½" x 1½"
- Non-glare glass
- 4-inch diameter official NASA designs
- Multi-colored
- Mounted on a deep blue panel

ASTRONOMY
Victory over Adversity: The Sh
LOUSMA
FULLERTON
COLUMBIA
Columbia
ENGLE-TRULY
Columbia
YOUNG-CRIPPEN

Framed NASA Emblems
— $29.95 —
postage included
Allow 6 to 8 weeks for delivery

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202. Sorry, but we cannot ship outside the U.S. except APO or FPO.

ASTROMART

WANTED — Equatorial mount for 60mm refractor with setting circles, clock drive, or slow motion controls. Contact Danny Flippo, 3720 Renee, Jonesboro, AR 72401. Phone (501) 935-7293.

WANTED — Volumes 2 and 3 of *Burnham's Celestial Handbook*. Will take the lowest offer under $8 per book. Send offers to Brian Stuhr, 810 NE 5th St., Marion, WI 54950.

WANTED — January and February 1980 *Sky & Telescope* magazine to complete my collection. Contact Wayne Little, 1360-48 Foothill Dr., Vista, CA 92083.

WANTED — HP 41C or HP 67/97 program "Orbital Elements of a comet (asteroid) from 3 observations of RA and DEC." Instructions and numerical examples appreciated — will pay postage and duplicating costs if reasonable. Send to C.E. Spratt, 1431 St. Patrick St., Victoria, BC V8S 4Y5, Canada.

PLÖSSLS FOR LESS!

You don't have to pay high prices to enjoy the exquisite definition offered by the 4-element Plössl design. Our University Plössls offer par-focal design, multi-coating, and are threaded for filters. 1¼" O.D. Start enjoying all the performance your telescope can deliver! Choice of 6 mm, 9 mm, 12.5 mm, 18 mm, 25 mm, and 40 mm. . . . . Each $45.00 ppd

Phone 313-665-3575

FREE CATALOG

Great savings on many types of eyepieces, binoculars, filters, and telescope parts! Specializing in accessories for Meade and Celestron!

VISA **University Optics** MasterCard

P.O. Box 1205

Ann Arbor, MI 48106-1205

WANTED — March 1969 issue of *Spaceflight*. Also *The Solar System* (1961) and *Rocket to the Moon* (1962), both published by Columbia Record Club. Contact Ronald Gallant, P.O. Box 5091, Redwood City, CA 94063.

WANTED — Back issues of ASTRONOMY: July 1974, September 1974, and January 1975. Contact Dick Dunlop, 2314 - 19th St. NW, Washington DC 20009. Phone (202) 483-8356.

WANTED — Mexican book on Mars, *El Planeta Marte*, by Elpidio Lopez and F.J. Escalante, 1963. Please state price and condition. Contact Carlos E. Hernandez, Avenida de Los Proceres, Edificio Laura Marcelle VII, Apto. #101, 1er Piso, Santo Domingo, Dominican Republic.

WANTED — Tektites. Collector seeking billitonites, australites, rizalites, bediasites, javanites, malaysianites and Ivory Coast tektites, Libyan Desert and Darwin glass. Send description and price to Tom Bannasch, 10835 Hansom Lane, Spring Valley, CA 92078.

WANTED — August 1960 issue of *Sky & Telescope* and *Review of Popular Astronomy*. Have older issues of *Sky & Telescope* for trade. Contact Kenneth R. Winovich, 349 Camfield Street, Pittsburgh, PA 15210. Phone (412) 381-9364.

FOR SALE — C-8, wedge, tripod, porro, Kellner 40mm, 25mm, 12mm and 9mm eyepieces, star diagonal, finger knob and polar alignment sets, 12 volt converter, dew gun, accessory case, all in excellent condition, $800. Contact K. Lucas, 5441 E. Via Buena Vista, Paradise Valley, AZ 85253. Phone (602) 948-8420.

Pre-Columbian Astronomers!

The Maya were superior astronomers: created an accurate calendar/predicted eclipses/mapped stars. Original rubbings of ancient Mayan ruins! Color catalog $2.00 (refundable with order).

BERNARDO
2400 Westheimer #108W (A-11)
Houston, TX 77098

FOR SALE — Meade illuminated reticle eyepiece system (1¼" O.D.), $35 plus shipping. Only 3 months old, used 2 or 3 times. Includes 12mm illuminated reticle and battery pack with rheostat. Contact Clint Anglin, 1122 Jackson St., St. Paul, MN 55117.

FOR SALE — Celestron 8, oculars, special coatings, wedge, tripod, solar filter, piggyback mount, matching dew cap, latitude adjuster, telecompressor, tele-extender, T-adapter, $1700 value for $1100. Contact Andre Hassid, 2277 Fair Oaks Blvd. #305, Sacramento, CA 95825. Phone (916) 758-2635 evenings, (916) 924-3355 during the day.

FOR SALE — Celestron 8, full solar filter for C-8, $199; cold camera, $199; original hardwood case for Quantum 6, $49. Contact Robert Hamm, RD #2, Box 603, Pawling, NY 12564.

FOR SALE — Edmund 4¼" Astroscan, has all original equipment except eyepiece. Few months old, like new, $135 COD. Contact Chad Lewis, 124 Rodney Plaza, Birdsboro, PA 19508. Phone (215) 582-3973.

FOR SALE — ASTRONOMY back issues from February 1975 to the present, mint condition. Best offer. Contact Brune DeRochi, 4172 Parker Ave., St. Louis, MO 63116. Phone (314) 773-4496.

FOR SALE — Hardcover astronomy books in near-perfect condition: *Black Holes, We Are Not Alone* (Walter Sullivan); *Genesis* (John Gribbin); *The Grand Tour* (Miller, Hartmann); *Voyage of Mariner-10* (NASA). Will accept best offers. Contact Ernie Janensch, 25749 W. Marion Ave., Ingleside, IL 60041.

FOR SALE — Apollo II planetarium complete with 22 programs, accessories, and 20-foot fiberglass dome. Contact Harold Seward, 3906 Grant St., Reading, PA 19606. Phone (215) 779-1963.

FOR SALE — Custom 10" classical Cassegrain: Coulter optics, Parks tube & finder, Novak hardware, Cave mount with dual-axis controls, 3.1" Meade guidescope. Several unique features, many accessories, everything works great. Must have $1600 or will consider trade for duplex or standard Questar. Contact Bob Schnitzer, 2070 Allen Blvd., Apt. #6, Middleton, WI 53562. Phone (608) 238-2616, or (608) 233-1607 after 6 p.m. and on weekends.

Commemorate Columbia's Final Test Flight With NASA's Official Emblem

The U.S. Space Shuttle *Columbia*'s 4th test flight is honored in this multi-colored 2½" x 4⅞" emblem. A red, white and blue streamer trails the Shuttle as it climbs to its highest altitude — 190 miles. On this last test flight before November's cargo-carrying mission, astronauts Ken Mattingly and Henry Hartsfield conducted thermal stress tests and extensive systems checks.

Columbia
MATTINGLY-HARTSFIELD

Columbia Mattingly-Hartsfield (STS 4), $4.50

To order, specify "STS 4 emblem" on the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

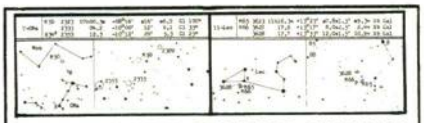
SALES AND SERVICE

TEXAS NAUTICAL

REPAIR CO.

PRODUCTS BY BAUSCH AND LOMB, BUSHNELL, CELESTRON, EDMUND, FUJINON, LEITZ, MEADE, NIKON, ORION, SWIFT, TELE VUE, AND ZEISS.

3209 MILAM
HOUSTON, TEXAS 77006
(713) 529-3551



INDEX CARD FINDER CHARTS

Made especially for use at the telescope!
75-Handy 3x5 star-charts per set

SET I - THE MESSIER OBJECTS $7.50
SET II - THE FINEST NGC OBJECTS........ $7.50
SET III - THE FINEST DOUBLE STARS....... $7.50
SET IV - THE FINEST NGC, Part B.......... $7.50

2 or more sets, $7.00 ea. 4 or more $6.50 ea.

SUPER 8 COLOR MOVIES

Jupiter, Saturn 1, Saturn 2, Universe, Sol. Sys., Sun, Space Shuttle, Apollo 10, 11, 12, 14, 15, 16, 17, **$26.95 ea.** With sound: Apollo 11, Space Shuttle, Universe, **$34.95 ea.** Send 37¢ stamp for FREE slide catalog. Outside USA add 20% extra for airmail postage.

ASTRO CARDS

P.O. Box 35, Natrona Heights, Pa. 15065

CELESTRON	Manufact. List	Our Price
C90 Telephoto	$325	$269 *inc. ship.**
C90 Spotting Scope	395	299 *inc. ship.**

CELESTRON	Manufact. List	Our Price
C5 Base price	$ 950	$689 *inc. ship**
C8 Base price	1050	777 *inc. ship**

EDMUND Astroscan "complete" $189 includes shipping in continental U.S.

MEADE 826 8" f/6 with drive $589 includes shipping in cont. U.S.

All Celestron and Edmund accessories are discounted 10% off mfgs. list and shipped free in cont. U.S.

TOMLIN f/6 6" reflecting telescope comes complete with Edmund clock drive mount and tripod. $349.

T-5 TRIPOD "Combination wedge & tripod," adjustable to all altitudes in the cont. U.S. Height adjustable for seating & observing positions. Works well with Celestron C90, C5 & Meade 2040 telescopes. Sturdy & light weight. *ONLY* $69 or $49 with the purchase of any of the above telescopes.

T-8 TRIPOD "Works with Celestron C8 & Meade 2080 wedges," and as an observing platform for Edmund Astroscan. Adjustable seating & observing positions. *ONLY* $59 or $39 with the purchase of any of the above telescopes.

TD-100 DRIVE CORRECTOR Precision tracking, hand-held, fast & slow override controls. Ideal for visual & photographic use. Variable speed control selects full range of sidereal, solar & lunar tracking rates. $79.

SOL-4 SOLAR FILTER — $39. For Celestron C-8, and Meade 2080.

All items sold by* **TOMLIN *are shipped free in the cont. US. Visa & Master Charge accepted. Personal checks allow two weeks to clear. Calif. residents add 6% sales tax. CATALOG PACKAGE — $6.00 postage paid (includes Celestron, Meade and Edmund Catalogs, plus over $200 of valuable coupons). Dealer inquiries about* **TOMLIN** *products are welcome.*

master charge THE INTERBANK CARD — *Tomlin Industries* — VISA

679 Easy St., (Dept. A), Simi Valley, Calif. 93065 Phone (805) 522-6646
Showroom open to Public — Mon. through Fri. 10 — 6. Sat. 10 - 4. For fast delivery, use your Visa or Master Charge and call free (800) 235-3344 (Orders only)

ASTROMART

FOR SALE — $12^1/_2$" Meade mirror, 2.60" and 3.1" elliptical flats with Novak holders, Meade model 680 focuser, 8x50 finder with brackets. Contact Clay Cooper, 524 Driftwood Circle, Slidell, LA 70458. Phone (504) 641-4638.

FOR SALE — Heavy duty spider mount. Fits $14^1/_4$" I.D. tubing, but could be cut down to fit smaller tubing. Brand new, $15. Also Newtonian diagonal holder, 2.25" minor axis, $6. Contact Greg Hinkle, 102 Woodview Dr., Williamstown, WV 26187.

FOR SALE — Meade 8x50 finderscope, $35 or will trade for $4^1/_4$" RFT reflector; Criterion 0.946" rack & pinion focuser with diagonal mirror, $15; eyepiece adapter, 0.965" to $1^1/_4$", $5. Contact Dan Isaac, RR1, Box 626, Danville, WV 25053. Phone (304) 369-2216.

FOR SALE — 8" f/5 reflector with Coulter mirror, fiberglass tube, 2 University Optics eyepieces, Pacific Instruments mount and drive, must pick up, $375. Contact Barry Foucault, P.O. Box 1843, Brown University, Providence, RI 02912. Phone (401) 421-5857.

FOR SALE — ASTRONOMY back issues, first issue to present, all in excellent condition, $200 plus shipping. Contact M.L. Krause, 2625 Ashley, Beaumont, TX 77702. Phone (713) 833-0228.

FOR SALE — Binoculars: 9x45 roof prism, integral filters, wide angle, $295; Ross, London, 10x50 wide angle, $300; Carl Zeiss 8x30 wide angle, $275; Argus spotting scope, 20x, all coated, excellent, $125. Contact Eugene Zaitarian, 317 Spencer Place, Paramus, NJ 07652. Phone (201) 262-3296.

FOR SALE — Selsi (Japanese-made) refractor telescope. 60mm aperture, f/13.3, coated optics. 12.5mm eyepiece with Sun filter, in good condition, ideal for beginners. Asking $50 or next best offer, you pay postage. Send SASE to Wallace Moyer, 444A Spring La., Sag Harbor, NY 11963.

CELESTRON

TELESCOPES • ACCESSORIES • BINOCULARS

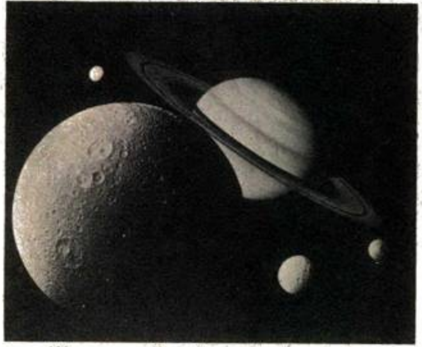
(713) 342-9890

Celestial Studios

1001 Lindsey
Rosenberg, Texas 77471

Send For **FREE DISCOUNT PRICE LIST**

Voyager Visions



We now offer five stunning full-color posters featuring highlights of the Voyager missions to Jupiter and Saturn. These posters measure 22½ x 29", are mailed rolled, and are suitable for framing.

- ☐ **APVJ-1 Jupiter**
- ☐ **APVS-1 Saturn**
- ☐ **APVJ-2 Jupiter with Four Moons**
- ☐ **APVS-2 Saturn with Six Moons**
- ☐ **APVS-3 Final Look at Saturn**

$8.50 for three posters
$13.00 for all five posters

($2.00 for complete catalog, credit applied toward next purchase)

Foreign orders add $2.00 for postage.

Satisfaction Guaranteed

Send check or money order to:

Hansen Planetarium

DEPT. A-11 1098 South 200 West
Salt Lake City, Utah 84101
Dealer inquiries welcome

Binocular Telescope Microscope
Sales and Service
20 Years Experience

Lawrence F. Reich
17 Columbus Ave.
No. Easton, Mass. 02356
Tel. (617) 584-9214 (617) 238-7343

STAR TRACKER

THE MOST COMPLETE TELESCOPE STORE IN THE KNOWN UNIVERSE

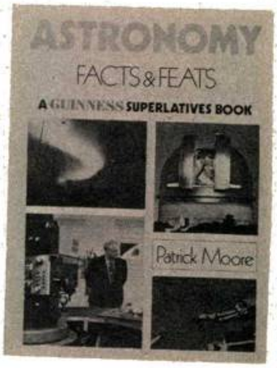
COME IN AND COMPARE

Write for the world's finest telescope Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

Astronomy Facts & Feats

by Patrick Moore



What was the largest meteorite to fall in Africa? In Ireland? When did the first probe land on the Moon? Who made the first telescopic drawing of Mars? Give up? Well, then you need a copy of this "Guiness Book of Astronomy"! Compiled by a noted British amateur astronomer and arranged by subject to make fact-finding easy, it's full of descriptions, lists, tables and photos. As an added bonus, there's a catalog of stars and observing objects arranged by constellation.

288 pages, hardcover **$18.50** postpaid

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

GLOBES FROM ASTRONOMY

Beautiful additions to your home, office, classroom or library. Accurate and sturdy, they are made by Replogle, the world's largest manufacturer of fine globes.

The Apollo

12" celestial globe shows 1,200 stars to 4th magnitude. Includes clusters, novae, doubles and the Milky Way! Gyromatic mounting in silver finish, complete with illustrated booklet.

16½" high $26.95

NASA Moon Globe

Official 12" globe with NASA-approved accuracy. Extremely detailed, it almost puts you on the surface of the Moon! Rests on a molded base and comes complete with booklet and study projects.

15" high $24.95

The Lenox

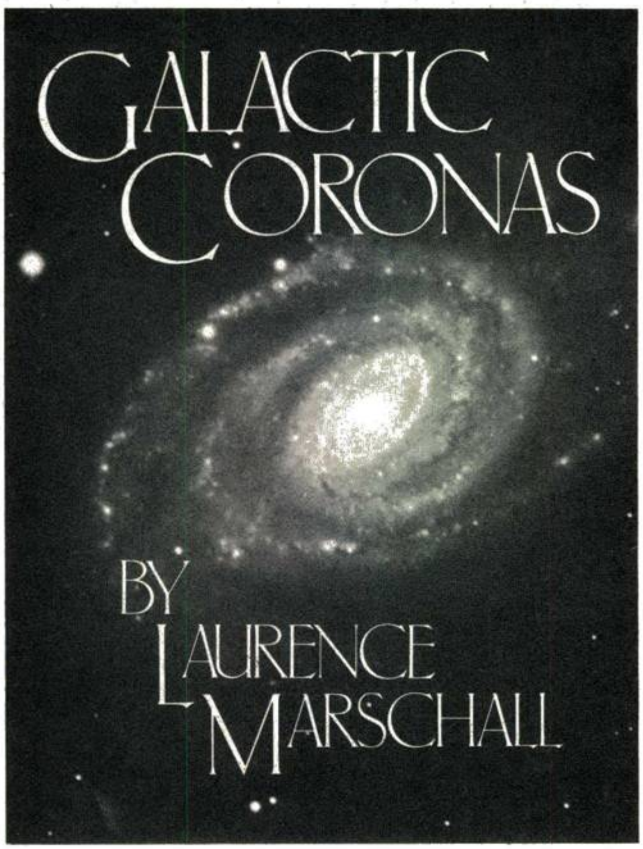
Beautiful 12" raised relief globe with parchment effects, cartouches and compass roses giving an elegance and charm to any room. Antiqued fruitwood finish on base and half meridian ring.

18" high $35.00

To order use the AstroMedia form bound into this magazine or send to AstroMedia Corp., P.O. Box 92788, Milwaukee, WI 53202. Sorry, but we cannot ship globes outside the U.S. except APO or FPO.

GALACTIC CORONAS

BY LAURENCE MARSCHALL



Hale Observatories photo.

At the limit of our telescopic vision, on the deepest photographs of the sky, images of galaxies crowd together more densely than stars. Though they take a variety of forms, the galaxies most commonly appear as spirals: huge pinwheels of glowing gas and luminous blue-white Suns. The shape of these cosmic whirlpools is so striking and distinctive that they have become an emblem of astronomy — as recognizable a part of nature as a rose or a robin.

Distinctive as these spirals are, their shapes are deceptive: recent research into the structure of galaxies suggests that the glowing forms seen in the sky by great telescopes may really be only the small, visible fraction of a much larger quantity of matter. If proven, this discovery is likely to alter our views, not only of how galaxies form and evolve, but also of the ultimate fate of the universe.

Our own Sun is a member of a spiral galaxy which seems typical of most spirals in size and shape. Although its overall pattern is not evident in the scattered distribution of stars in the night sky, our Galaxy is so vast that every star we see with the naked eye is a member of it. Because it is narrow in one dimension and extensive in another, the Galaxy appears as a ragged ribbon of faint light, known since antiquity as the Milky Way. A soft glow to the naked eye, under the scrutiny of a telescope the Milky Way resolves into hundreds of thousands of stars mixed with clouds of glowing gas and dense banks of obscuring dust.

To map the structure of a spiral galaxy, you might think we'd need only count and measure all of the objects we see in our own Milky Way. But it's not as easy as that. While we can determine the distance to nearby stars rather accurately, the reliability of our measurements decreases greatly beyond a few hundred light-years — only a fraction of the distance across the stellar system. Our difficulty is compounded by the pervasive presence of dust, a kind of interstellar haze that makes it impossible to survey optically more than a small part of the Galaxy. Stars beyond a few thousand light-years from the Sun are hidden from our sight.

Over the past three-quarters of a century, astronomers have been drawing together indirect evidence from a variety of sources to overcome these problems and reveal the grand overall design of spiral galaxies like our own. A first line of evidence, developed by Harlow Shapley in the early decades of this century, uses the distribution of globular star clusters to pin down the location of the center of the Galaxy. The globular clusters — spherical swarms containing hundreds of thousands of stars each — are seen above and below the plane of the Milky Way, away from the largest concentrations of gas and dust. As we see them unobscured, we can map them out to great distances and determine their patterns of distribution in space.

What Shapley found was that the globular clusters seemed to be scattered uniformly around a point about 30,000 light-years away, in the direction of the constellation Sagittarius. Though this point is hidden behind light-years of dust, we believe it is the center of our Milky Way Galaxy. Later measurements determined that our own Sun and its neighboring stars orbit around this center once every 250 million years. Since our solar system formed 5 billion years ago, we have circled the galactic center some 20 times, traveling almost 4 million light-years in the process.

Further major advances in our understanding of galaxies took place in the 1950s and '60s, when radio astronomers began to map the Milky Way by tracking radiation emitted by atoms of neutral hydrogen, the most abundant gas in the space between the stars. This radiation has a wavelength of 21 centimeters and easily penetrates the dense dust that blocks the much shorter visible wavelengths emitted by stars. Radio telescopes can thus "see" into regions of space where optical telescopes are blind. Both the amount of hydrogen gas and the velocity of its motion with respect to the Earth can be calculated from these 21 centimeter signals. This enables astronomers to determine the position and flow patterns of the gas clouds that seem to accompany the stars in their motions around the galactic center.

The picture of a typical spiral galaxy that has emerged from this research has two components. The first is a flat disk almost 100,000 light-years in diameter but only some 1000 light-years thick. All the gas and dust clouds of the galaxy, and most of its stars, are concentrated in the disk. The brightest and most conspicuous stars of the disk are arranged in the spiral patterns that are so striking when viewed from afar.

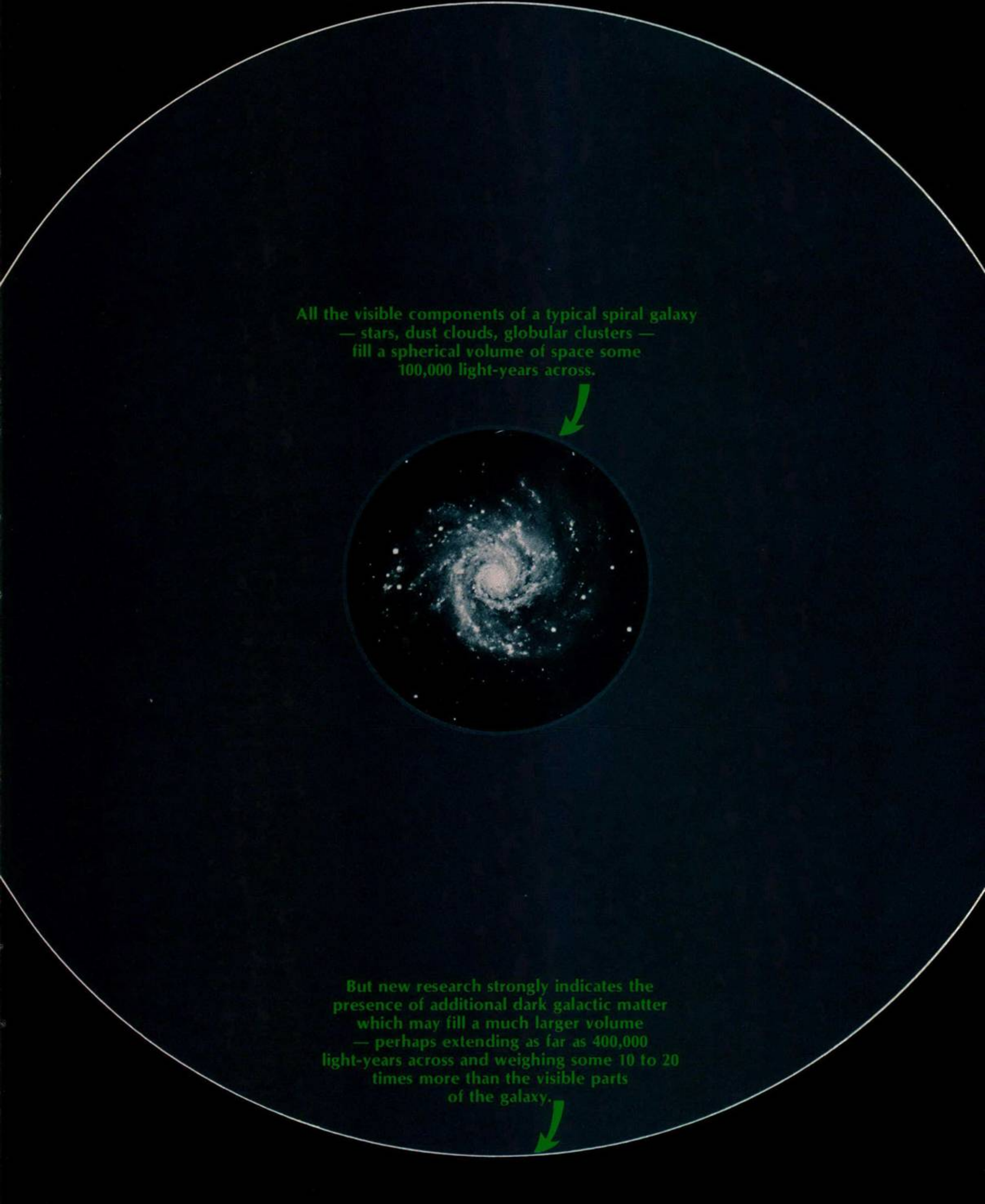
In the Milky Way and many other galaxies, the central portions of the disk seem to be swollen into a large nuclear bulge, several thousand light-years in diameter. But because clouds of dust hide the center of the Galaxy, the bulge of the Milky Way is one of the least-known regions of our stellar system. (See "Journey to the Center of the Galaxy," ASTRONOMY, August 1980.)

The second component of a spiral galaxy is the *halo*, which is composed primarily of the globular clusters we mentioned earlier. These are scattered randomly in a rough sphere with a diameter equal to that of the disk: 100,000 light-years. While stars in the disk travel in roughly circular orbits around the galactic center, globular clusters move in highly-elongated orbits, spending most of their time far from the central regions, and only occasionally swooping down through the plane of the disk. Though globular clusters appear dim at great distances, we have recently detected them in the halos of a few nearby galaxies, such as M-31 in Andromeda.

One question astronomers want to answer with this two-component model is how much does one of these galaxies weigh, or, in scientific terms, what is its mass? To begin, we might try to determine how many stars there are in a typical spiral. One obvious, if tedious, approach would be to tally all the stars that appear on photos of the Milky Way. But here, because of the limited region of unobscured space we can survey, our sample is far from complete. Assuming that our Galaxy is typical, however, we can measure the light given off by other spiral galaxies and

Kitt Peak National Observatory photo.

The Corona of a Spiral Galaxy



All the visible components of a typical spiral galaxy — stars, dust clouds, globular clusters — fill a spherical volume of space some 100,000 light-years across.

But new research strongly indicates the presence of additional dark galactic matter which may fill a much larger volume — perhaps extending as far as 400,000 light-years across and weighing some 10 to 20 times more than the visible parts of the galaxy.

calculate roughly how many solar-type stars would be required to produce it. Such studies yield star counts of from 100 to 200 billion stars in a typical spiral, with each star being, on average, as massive as our Sun.

Another way to find the mass of a galaxy is to make use of the law of gravity. Since individual stars feel the gravitational tug of all the material in a galaxy, the orbital velocity of a star at a given point is a measure of the mass of that galaxy. Studies of the velocities of stars near the Sun and of the orbits of globular clusters give results that generally agree with the estimates made by measurements of a galaxy's light output.

But our simple two-component model of galactic structure cannot explain all the observations of spiral galaxies we have accumulated over the last few decades. Astronomers are beginning to suspect that there is much more to these cosmic pinwheels than meets the eye, that perhaps as much as 90% of the matter in our Galaxy and others has escaped detection — until recently.

In the early 1970s, astronomers noticed a discrepancy between the masses of galaxies estimated by measuring their light output (their "luminosity masses"), masses measured by determining the speed of orbital rotation of stars ("rotational masses"), and masses estimated by a third method which could only be applied to galaxies which were members of large clusters of galaxies.

In the third method, astrophysicists measure the distribution of velocities among the galaxies in a cluster. According to a principle of physics called the *virial theorem*, the larger the total mass of the cluster, the more variation in speed there should be among the various members of the cluster. If all the galaxies were of very low mass, each would travel at about the same speed; if the cluster contained more massive galaxies, we would detect a wider spread of velocities.

These "virial masses" were usually found to be 10 to 20 times higher than the estimated luminosity or rotational-masses for the same galaxies. Clearly one figure was wrong, but which? Should we trust the two lower values, which were in agreement, or should astronomers conclude that the generally accepted figure of 100 billion solar masses per galaxy somehow overlooked a huge portion of the material in the universe?

In 1974, several groups of astronomers presented independent arguments supporting a higher mass for the galaxies. Jaan Einasto, Ants Kaasik, and Enn Saar of Tartu Observatory in Estonia published a study of more than a hundred binary galaxies — close companions which circled one another under the influence of their mutual gravitational interaction. From the velocities of the galaxies, the astronomers determined their masses. The figures ranged upward as high as 10 trillion times the mass of the Sun, far higher than the 100 billion figure commonly accepted at the time.

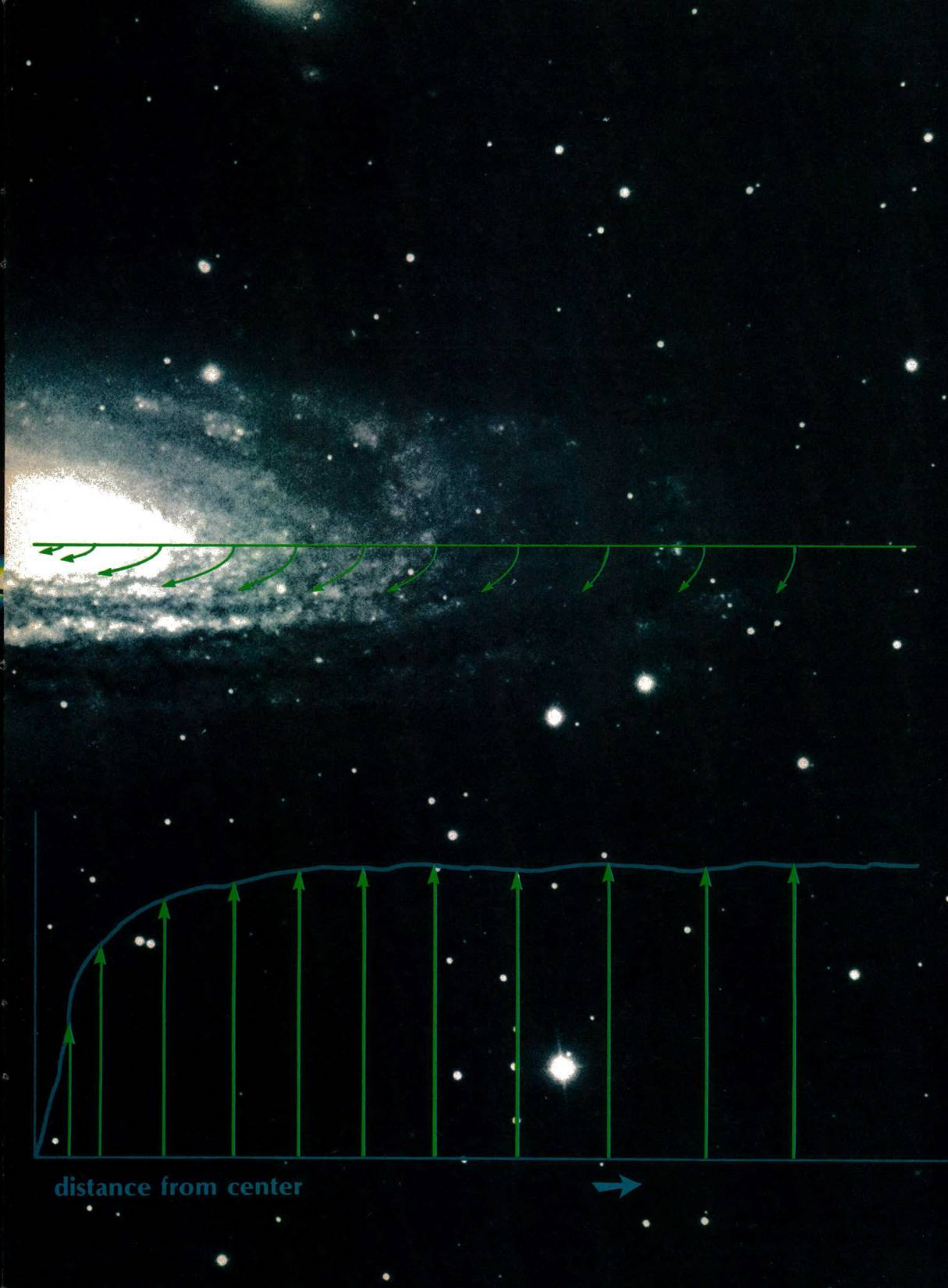
The results also seemed to show that the greater the distance separating a pair of galaxies, the more mass there appeared to be. Since orbiting objects sense primarily the mass lying between them and the center of their orbits, the results suggested simply that the more widely separated binary galaxies moved under the influence of mass that ordinarily lay beyond the orbits of the closer galaxies. This in turn suggested that galaxies might be surrounded by massive spheres of unseen matter that extend far beyond the bounds of disk and halo. Einasto and his collaborators believed the evidence for such a mass was compelling — and called this new component of a galaxy the *corona*.

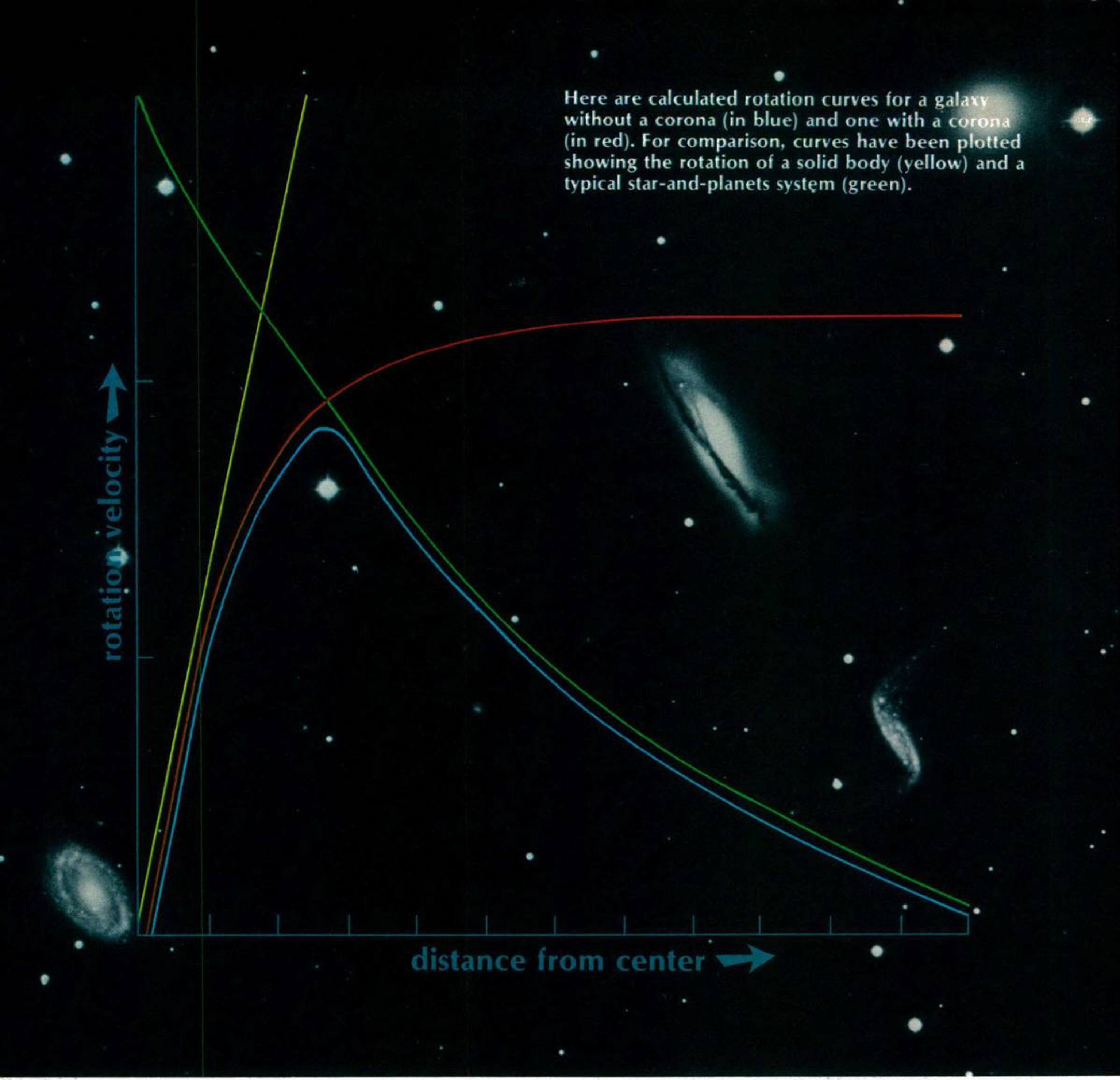
At the same time, Jeremiah Ostriker, P.J.E. Peebles, and Amos Yahil of Princeton University argued that theoretical considerations required the presence of enormous spheres of undetected material surrounding galaxies. Were this not so, they claimed, the relatively thin disks of the galaxies would be unstable and their delicate pinwheels would distort under the gravitational forces of their own stars and

The rotation of a spiral galaxy ought to show a drop in velocity at the visible edge, but repeated observations have shown that rotation is constant even at great distances from galactic centers. Dynamically, this implies that large quantities of galactic matter exist beyond the visible edge of a spiral galaxy.

rotation velocity

Hale Observatories photo.


distance from center



Here are calculated rotation curves for a galaxy without a corona (in blue) and one with a corona (in red). For comparison, curves have been plotted showing the rotation of a solid body (yellow) and a typical star-and-planets system (green).

Hale Observatories photo.

other nearby objects. A massive and extensive corona — far larger than the halo of globular clusters — could provide this stabilizing influence and preserve the intricate visible structure of a spiral galaxy much as a glass teardrop can be suspended in a ball of crystal. Not only did the astronomical clues suggest galactic coronas, but the laws affecting gravitational disturbances seemed to demand them.

But had these been the only voices calling for a revision in our views of the Galaxy, astronomers would have been reluctant to believe that such gargantuan quantities of matter could exist undetected for so long. What were we to make of the earlier evidence gathered from the light output of galaxies and from the rotation of their stars? Where was all this alleged mass hiding?

Simple, said the supporters of the corona hypothesis: only virial masses, which alone are based on the motions of galaxies in very large volumes of space, can be trusted to give a complete survey of galactic material. The other two methods of "weighing" galaxies unavoidably miss much of what is there.

Why? First of all, the material in a galactic corona — whatever it is — must be very cool and dark since it does not emit much light or radio radiation. Thus it never turns up in estimates of the mass of galaxies derived from luminosity measurements. Second, the rotational masses of galaxies are based mainly on those portions of a galaxy *inside* the orbits of the stars that are measured. Forced to use some figure in their calculations, astronomers had made educated guesses of the extent and quantity of the outlying material. But what if the guesses were wrong? What if 90% of the mass of galaxies was dispersed beyond the clearly observed edge of the disk and halo? If this were true, then clearly the earlier masses would have been drastically low. Sample stellar velocities farther from the center of galaxies, said the corona supporters, and you will find evidence for more mass than was previously believed possible.

That work has now been done. Since 1975, a continuing series of studies on the rotation of spiral galaxies has been carried out by Vera Rubin, W. Kent Ford Jr., and Norbert Thonnard of the Carnegie Institution of Washington. Their results strongly support the suspicion that all spiral galaxies are immersed in an immense corona of unseen material.

The Carnegie researchers have taken many spectra — from the center of a galaxy to its faint outer fringes — for a number of distant spiral galaxies. Since the light from these galaxies is very weak, astronomers must use the largest telescopes and most sensitive detection equipment to obtain spectra of the crucial outer spiral arms.

The Doppler shift of lines in the spectra of these distant galaxies enabled researchers to compute the velocity of stars at varying positions in each spiral galaxy they studied. This information can be displayed as a rotation curve, a plot of velocity versus distance from the galaxy's center. If the old two-component model were right, most of the mass of a galaxy would be concentrated within 20 or 30 thousand light-years of the center. Since stars farther out than this are more distant from the source of gravitation, they orbit more slowly, and the rotation curves would diminish at the outskirts of the galaxies.

As it happens, the rotation curves look nothing like this. In virtually every case studied, they seem to level off: stars as distant as 150,000 light-years from the center seem to rotate with the same velocity as stars closer in. This indicates that the gravitational field of a galaxy is far more extensive than previously believed, that the mass of the galaxy is spread out over a much larger volume, and that the location of this invisible mass is probably the corona suggested by the groups at Tartu and at Princeton.

But some things are too close for easy contemplation, and this is the case with galaxies. It is far easier to measure their rotation when we view them as a whole from afar, than when we see them from within. Nevertheless, a few meticulous investigators have attempted to follow the rotation curve of our own Milky Way into regions well out beyond the Sun. Recent observations of very distant globular clusters, orbiting satellite galaxies such as the Magellanic Clouds, remote stars in the disk of our Galaxy, and of neutral hydrogen molecules, all indicate that the orbital velocity of objects in our own Galaxy stays remarkably constant out to large distances from its center. The jury is not in yet, but it seems likely that future astronomy textbooks will show a third major component of spiral galaxies: the corona.

What does this galactic corona look like? And what is it made of? At present we do not know — though we can rule out certain possibilities. If the corona of our Galaxy were composed of stars of average brightness, it would have been photographed long ago. If it were composed of clouds of cool hydrogen gas, we would have detected 21-centimeter radio waves from it, or noticed a tell-tale absorption of light from distant galaxies. If it contained much dust, it would block light in a similarly detectable fashion. Astronomers have seen none of these effects despite careful searches.

Perhaps the galactic corona consists of enormous numbers of stars of very low mass and very low luminosity. Long-exposure photographs of nearby galaxies might reveal swarms of these dim stars, but studies so far have been inconclusive. The principal method of detecting them would be to look for a weak glow of light surrounding the much brighter image of a galaxy. But looking for this glow pushes observational techniques to their limit since they require long exposures and sensitive detectors. Distinguishing the glow of a galactic corona from the normal background of the night sky may be nearly impossible, and it's likely this method will have to await the Space Telescope.

Yet we may have another way to detect these stars. Richard Gott has suggested that if a galaxy with a massive corona of faint stars lay directly between us and a more distant quasar, the mass of the corona could bend light around the edges of the galaxy and intensify the image of the distant quasar. This gravitational-lens effect has been noted for several galaxies so far (see "Gravity Lenses: A Focus on the Cosmic Twins," ASTRONOMY, July 1981). The motions of these faint stars would introduce a slow shimmering or scintillation into the gravitationally-intensified image of the distant quasar. No observations of this phenomenon have yet been made, but in time it could provide evidence for massive coronas being made of stars.

It is also possible that the corona may consist entirely of dead stars — stars which have exhausted their nuclear fuel and have cooled below the limit of visibility. These may be black or brown dwarfs, cool neutron stars, or black holes. In these cases, they would probably never be directly detectable either in our Milky Way or in other galaxies. The corona would thus remain a phantom — we would sense its presence but not see it.

Theoretical astrophysicists have recently suggested that the neutrino, a subatomic particle produced in great numbers in the cores of stars, might have a small amount of rest-mass. Previously it had been thought that neutrinos, like photons, had essentially zero mass. But if neutrinos have even a minute mass, they would contribute a sizeable share to the mass of a galaxy, since there are about 100 million neutrinos for every atom of hydrogen in the universe. A neutrino-filled corona would be invisible and undetectable except by such indirect methods as the rotation-curve analysis.

The significance of galactic coronas goes far beyond the challenges they pose to observers or the hint of something immense that can't be seen. Coronas, if they do exist, may provide an answer to a question that is central to modern cosmology: what will happen to the universe in the distant future?

We know that galaxies are receding from us, evidence of the universal expansion of space that began between 10 and 20 billion years ago in what astronomers call the Big Bang. There are two possible outcomes for this expansion. If there is enough matter in the universe, it will slow the expansion and reverse it, just as the Earth's gravitation slows the upward flight of a baseball and brings it back to the ground. The resulting collapse may be followed by another Bang, and a continuing cycle of expansion and collapse may result.

If the matter in the universe is spread too thinly, the expanding universe may never halt its headlong flight to oblivion. The expansion would continue forever until all the stars burned out and space reached a uniform temperature near absolute zero.

When all the detectable matter in the universe is accounted for, it amounts to no more than 5% of the mass required to stop the expansion. As a result, most astronomers believe that the universe is "open" rather than "closed," and that the expansion is a one-time affair that will never be reversed. But if galactic coronas are proven to be massive components of galaxies, they could harbor enough material to arrest the outward rush of the universe, and — assuming the collapse leads again to an expansion — we could be riding one recurrence of an endless series of cosmic bounces.

All this, of course, is on a much higher level of speculation than the existence of galactic coronas themselves. Surely we will not be around 10 billion years from now to be thrilled by the "Big Implosion" or to be disappointed by the dissipation of the universe. But within the next few years we will continue to get a sharper focus on the overall structure and the hidden complexity of those beautiful celestial question marks, the spiral galaxies.

Laurence Marschall is associate professor of physics at Gettysburg College and director of its observatory and planetarium. His research interests center on proper-motions in young open clusters. His last article for ASTRONOMY was "Secrets of Interstellar Clouds" in the March 1982 issue.

ASTROMART

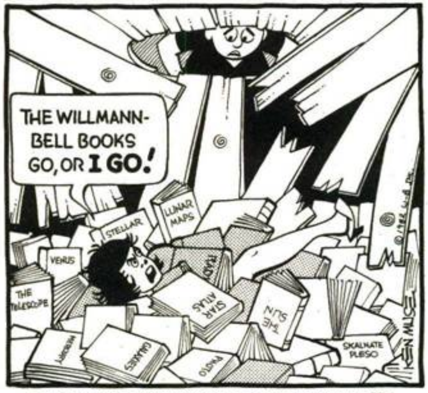
FOR SALE — New, mint, unavailable complete issues of the *New York Times* with full-page space headlines of history — Glenn orbit through Apollos to Viking. Valuable, replated finals late edition. $100 to $700 each, according to date. Contact Peter Leavens, P.O. Box 500, Merrick, NY 11566.

FOR SALE — Dynamax 8, carrying case, three eyepieces, star diagonal, golden field tripod, drive corrector, focal reducer, Sun and Moon filter, $975. Contact David Nicholson, 8374 Dudley Court, Arvada, CO 80005. Phone (303) 422-4566.

FOR SALE — Edmund 3" f/10 telescope. Excellent condition, one year old, $110, you pay shipping. Contact David Gray, 1010 Poppy Dr., Wapakoneta, OH 45895.

FOR SALE — *Catalogue of the Universe* by Murdin and Allen, brand new, $15.65. Contact M.M. Renner, Route 1, Allons, TN 38541.

ASTRONOMY BOOKS & SUPPLIES



FOR A HUGE CATALOG SEND ONE DOLLAR TO
WILLMANN-BELL, BOX 3125G, RICHMOND, VA. 23235

FOR SALE — ASTRONOMY back issues, October 1978 through August 1982; *OMNI* back issues, March 1981 to present; *Science Digest*, April 1981 to present; *Sky & Telescope*, November 1978 through September 1981. All issues $1.50 each. Contact William Blair, 1900 Highview Rd., Apt. D-1, East Peoria, IL 61611.

FOR SALE — Every ASTRONOMY back issue, August 1973 to the present; best offer. Also many back issues of *OMNI, Analog, Modern Photography, Popular Photography, Petersen's Photographic*. Contact Dennis Rebertus, 8859 W. Friend Ave., Littleton, CO 80123.

FOR SALE — Old *Popular Science* magazines, science fiction/fact books. Send SASE for list. Contact Michael Barnett, 2278 Halsey St., Union, NJ 07083.

FOR SALE — Two complete sets of brand new Edmund RKE eyepieces — 8mm, 12mm, 15mm, 21mm and 28mm. Standard $1^{1}/_{4}$", threaded for filters, with custom cases. Worth $165 for the set, will take best offer. Contact Bryan Lovitz, (215) 885-7864, from 6 to 10 p.m.

FOR SALE — 80mm equatorial refractor, five eyepieces (22mm, 12.5mm, 9mm, 6mm, 4mm), star diagonal prism, image erecting prism, Barlow lens, Sun projection screen — all lenses in excellent condition. Asking $375. Contact Greg McKay, 708 Welwyn Way, Alexandria, LA 71301.

FOR SALE — Several miscellaneous audio tapes on the Space Shuttle missions and program. Will sell as a set or individually. Send SASE to R. Gudyka, Box 143, Pe Ell, WA 98572.

CELESTRON TELESCOPES
ON DISPLAY AND IN STOCK
E & W OPTICAL INC.
2420 EAST HENNEPIN AVE
DEPT AM
MINNEAPOLIS, MINN 55413
612-331-1187
SEND FOR PRICE LIST "A"
Astronomy supplies and accessories

FOR SALE — Dynamax 8 telescope with all accessories, tripod lens, filter, handbook and material, fully coated, used only twice, $1000. Contact J. Addington, Box 67, Jumping Branch, WV 25969.

FOR SALE — Brand new Edmund Scientific Voyager 2001 refractor telescope. No scratches on lenses or outer covering, in perfect condition. Comes with user's manual, tripod, RKE 15mm lens, and prism. $200 plus postage. Contact Eddie Silvers, Jr., 1053 Turnersville Rd., Pine Hill, NJ 08021.

FOR SALE — Meade 2x-3x variable Barlow, list $40, will sell for $20. Celestron #4 L.P.R. filter for $1^{1}/_{4}$" eyepieces plus adapter, list $65, will sell for $35. University Optics Koenig eyepieces (8mm, 12mm, 16mm, 24mm, 32mm) and Duramite eyepiece containers for each; list $225, sell for $110. Shipped UPS. Contact Gordon Smith, 416 Elmhurst, Parchment, MI 49004. Phone (616) 349-6019.

FOR SALE — Skylog research notebook, never been used. Originally cost $24, will sell for $15. Contact Dan Vap, 9387 Miller Creek Road, Missoula, MT 59803.

FOR SALE — Computer programs for astronomical purposes. Buy one? Sell one? Complete listing service. Send SASE for details, stating Buy, Sell, or Both. Contact L.S. Blanchard, 23509 Hendlund Ave., Mountlake Terrace, WA 98043.

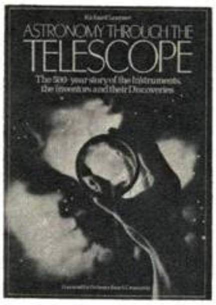
FOR SALE — Jason 60mm refractor; 43, 76, 91, 227x oculars, 2x Barlow lens, equatorial mount, slow motions, 10x reflex finder, wooden tripod, solar-lunar filters, correcting and erecting prisms. $130. Contact Chuck White, 1031 Ironwood Ct., Apt. 102, Rochester, MI 48063. Phone (313) 656-0744.

FOR SALE — Questar standard $3^{1}/_{2}$" telescope with Cer-Vit mirror and broad-band and low reflection coatings. Also astro Polaroid camera, camera coupling set, and extra tripod. Mint condition, $1395. Contact Marshall Mann, 4102 W. Orchid Lane, Phoenix, AZ 85021. Phone (602) 939-8555.

FOR SALE or trade — Spencer and B&L binocular eyepiece attachments, surplus 16" square x $1^{1}/_{4}$" and 15" square x $^{3}/_{4}$" front surface mirrors, objectives, eyepieces, lens, prisms, etc. Need 10x50 Zeiss binoculars and 14" to 16" blank or mirror. Contact John Porter, 2423 Crow Creek Dr., Dallas, TX 75233. Phone (214) 331-2267.

Astronomy Through the Telescope

by Richard Learner


Richard Learner
ASTRONOMY THROUGH THE TELESCOPE
The 500-year story of the Instruments, the Inventors and their Discoveries

This richly illustrated, large-format book recounts the history of astronomy since the invention of the telescope — the instrument that has revolutionized our view of the universe more than any other. From Galileo's little 30x "optik tube" to the 10-meter giants of the Next Generation Telescope projects — the full story is here.

Hardcover, 208 pages $29.95 postpaid

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

COMPUTER OWNERS:

INCREASE THE ENJOYMENT OF YOUR DOBSONIAN WITH OUR ADVANCED ASTRO SOFTWARE.

SEND FOR FREE SOFTWARE/HARDWARE CATALOG.

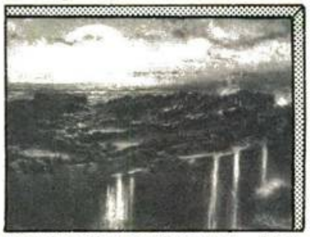
K & W ASTRONOMICS

P.O. BOX 2275
ORANGE, CA 92669

SPACESCAPES

by Don Dixon

COLOR PRINTS



COLOR SLIDES

ASTRONOMICAL ART

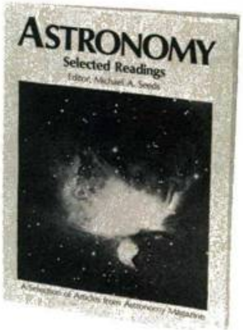
Send $2.00 for New illustrated catalog

DIXON SPACESCAPES, 25022 Chestnut St.
Newhall, CA 91321, U.S.A.

ASTRONOMY: SELECTED READINGS

edited by Michael Seeds

A Selection of Articles from ASTRONOMY Magazine.



A gloriously colorful anthology of 11 of the best articles run in ASTRONOMY. Covers the whole range of astronomical research.

178 pages, paperback, $11.50

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Corp., Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ASTROMART

FOR SALE — Celestron 14 mount including Tuthill digital readouts (AstroNavigator). (We bought a Byers mount.) $1500 or best offer. Contact Prof. J.M. Pasachoff, Hopkins Observatory, Williams College, Williamstown, MA 01267. Phone (413) 458-8346.

FOR SALE — Celestron 14, special coatings, tripod and wedge, all standard accessories, three years old, excellent condition, beautiful performer. $4850 or best offer. Contact Greg Gardner, Box 487, 120 W. Tweedy St., Hustisford, WI 53034. Phone (414) 349-3724.

FOR SALE — To settle estate. Solar complex: complete 10" diameter low-scattered-light solar telescope, spectrograph, Anderson's rotating prisms, spectrohelioscope, filter and miscellaneous optics available as a whole unit. Write for description. Contact Mrs. B.C. Parmenter, P.O. Box 814, Show Low, AZ 85901. Phone (602) 537-2144.

FOR SALE — ASTRONOMY back issues as set, August 1973 through July 1977. Excellent condition, best offer. Contact John C. Gorka, 5293 Bridgewater Road, Cleveland, OH 44124. Phone (216) 442-1025.

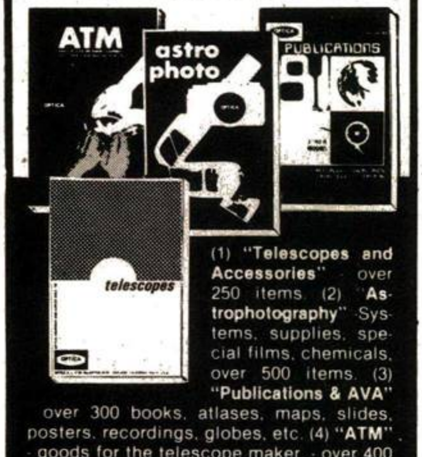
FOR SALE — 10" f/6 Cave telescope complete with four eyepieces, electric declination, 12-volt drive corrector, $800. Contact Ronald Nagle, 3144 Ladoga Ave., Long Beach, CA 90808. Phone (213) 531-8673.

FOR SALE — Three hardcover astronomy books: *The Cambridge Encyclopedia of Astronomy*, by Simon Mitton, 1977, publisher's price $40; *We Are Not Alone*, by Walter Sullivan, 1966, publisher's price $7.50; *Black Holes: The Edge of Space, the End of Time*, Walter Sullivan, 1979, publisher's price $17.95. Will accept best offer. Contact Ernie Janensch, 25749 W. Marion Av., Ingleside, IL 60041.

METEORITES

AVAILABLE TO
ASTRONOMERS, SCHOOLS
INSTITUTIONS AND PRIVATE
COLLECTORS. STONES & IRON
SPECIMENS. **LIMITED SUPPLY.**
ROBERT A. HAAG — METEORITES
2990 E. MICHIGAN DR., TUCSON, AZ 85714
SEND FOR FREE CATALOG / 602/882-8804

4 OPTICA b/c CATALOGUES



(1) **"Telescopes and Accessories"** over 250 items. (2) **"Astrophotography"** Systems, supplies, special films, chemicals, over 500 items. (3) **"Publications & AVA"** over 300 books, atlases, maps, slides, posters, recordings, globes, etc. (4) **"ATM"** - goods for the telescope maker - over 400 items. Each catalog - $1.00; all four - $3.00. Also Receive: **FREE** Astronomical Events Calendar, a wealth of useful information, current discount price list and coupons. **FOREIGN** must add $3.50 for Airmail and send international postal money order or check drawn in U.S.$ on any U.S. bank. Astro equip. & supplies since 1939. Astro Aids, Celestron, Bushnell, Stellar Ventures, OPTICA b/c, Von Werner, B&L, etc.

OPTICA

OPTICA b/c Company
ASTRONOMY DIVISION
4100 MacArthur Blvd., Oakland, Calif. 94619

FOR SALE — Celestron C-8, coated, wedge, accessories, but no tripod. $600. Contact D.P. Scott, 77 Shawomet, Warwick, RI 02889. Phone (401) 738-2681.

FOR SALE — Six-inch, f/4 Newtonian. Adjustable equatorial mount, home made design. Fine deep-space telescope, in good condition, asking $125. Contact Scott Boothroyd, 3022 Kenilworth, Kalamazoo, MI 49001. Phone (616) 343-3670.

FOR SALE — Criterion RV-6 Dynascope with mount, setting circles, drive, 2 oculars, etc. Like new condition, asking $320 or best offer, will ship. Contact Wong, 225 Academy St., Jersey City, NJ 07306. Phone (201) 420-0270.

FOR SALE — Cave 12.5" f/6 reflector. Heavy equatorial mount, electric drive. New optics: 12.5" mirror, 8x50 finderscope, 2.4" tracking scope, 2" eyepiece. May be mounted on pedestal or pier, not included. Best offer. Phone R. Schweinfurth, (205) 962-2283.

ORIENTAL ECLIPSE EXPRESS

11 JUNE 1983 SOLAR ECLIPSE
THAILAND, MALAYSIA, INDONESIA

HONG KONG • BANGKOK • AYUTTHAYA
ISLE OF PENANG • MALACCA
SINGAPORE • JAKARTA • BOROBUDUR
PRAMBANAN • MT. BROMO • BALI
MALAY PENINSULA AND JAVA TRAVEL BY RAIL

$3995	**23 days**
$3195	**15 days**

ORIENTAL ECLIPSE EXPRESS
737 Pearl Street, Suite 210
La Jolla, California U.S.A. 92037
Phone (619)* 459-7250
*Use a/c 714 prior to Nov. 1982

FOR SALE — Celestron C-90 telescope with factory accessories plus 30mm and 60mm oculars, T-adapter and T-rings to fit Minolta SRT-101. Asking $425. Contact Thomas K. Swain, 316 E. McClure Circle, Castle Hayne, NC 28429. Phone (919) 675-2886.

DON'T BE BLIND!
Add our specially-optimized
ULTRA-RED FILTER
to your flashlight. Preserves night vision better than any red flashlight on the market. Filter, instructions $3. **FREE** with order, 6-page booklet *Human Dark Adaptation* and complete optics catalog.

DEY OPTICS, Box 92313, Rochester, NY 14692

original sterling silver
SILVER MOON
design
$24.95

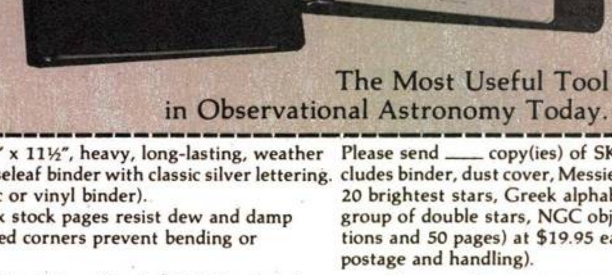
actual size

please specify pendant with 18" silver chain **or** pin/pendant combo w/o chain

send ck or m.o: jessica felix designs
288 guerrero, san francisco ca 94103
free brochure: 5 planets, 8 galaxies
wholesale inquires (415) 552-8673

THE ONE ACCESSORY YOU'LL USE MORE THAN ANY OTHER

SKYLOG™ **ASTRONOMICAL RESEARCH NOTEBOOK**


SKYLOG
ASTRONOMICAL RESEARCH NOTEBOOK
SKYLOG
ASTRONOMICAL RESEARCH NOTEBOOK

FOREIGN ADD 10%

The Most Useful Tool in Observational Astronomy Today. **$19.95** Complete

- Large 10¼" x 11½", heavy, long-lasting, weather resistant looseleaf binder with classic silver lettering. (Not a plastic or vinyl binder).
- Thick index stock pages resist dew and damp air. Rounded corners prevent bending or tearing.
- The 20 brightest stars, Greek alphabet, selected group of double stars and NGC objects.
- FREE Messier Catalog.
- Features protective thick plastic dust cover.
- Immediate delivery.

Phone: (804) 340-2850
Astronomical Societies, Colleges, Schools, Universities-Write for Quantity Discounts.

Please send ____ copy(ies) of SKYLOG (includes binder, dust cover, Messier catalog, the 20 brightest stars, Greek alphabet, selected group of double stars, NGC objects, instructions and 50 pages) at $19.95 each (includes postage and handling).

Please send check or money order to:
SKYLOG
4001 W. Colonial Pkwy., Va. Beach, Va. 23452

Name ____________________
Address ____________________
City ____________________
State ____________ Zip ____________ A

gazer's gazette

21 objects for binocular observers

by Brian Jones

Many people are under the impression that making astronomical observations calls for owning a large and expensive telescope, but nothing could be further from the truth. Naked-eye observing is essential with some celestial objects — aurorae and meteors, for example — and many others show up best in the low-power, wide fields of binoculars.

In fact, binoculars are among the most useful pieces of astronomical equipment you can own. (See "Seeing Double" on page 39 of this issue.) I do something like three-quarters of my observing with my trusty 10x50 binocs — and I also own a 6-inch Newtonian reflector, so I don't just use binoculars by default.

Apart from optical quality, the difficulty of holding a pair of binoculars steady has a major bearing on their usefulness. For best results, you should brace yourself against a tree, a fence, a part of the house, or a utility pole, or attach your binocs with masking tape or rubber bands to a photo tripod.

Still another method is to buy one of those adaptors (sold by most binocular manufacturers) that clamp onto the center shaft of the Porro prism type. These adaptors have a hole in the bottom tapped to accept the standard ¼-20 thread that photo tripods use. Getting the binocs out of your hands and onto a tripod will greatly reduce distracting image motions and let you really begin to look.

Over the years I've been using binoculars, I've found that some celestial objects rank as personal favorites. My reasons for choosing these particular 21 are varied. With some objects you can easily see features, such as the craters and maria on the Moon. Others offer an observing challenge: the Dumbbell Nebula and M-33 both hover on the point of invisibility. And finally, some of them — such as the Orion Nebula — are simply beautiful to look at.

Before getting into the list proper, one disclaimer is in order: Because I live in the British Isles at a latitude near +53°, I can't properly observe the magnificent run of Milky Way objects in Scorpius and Sagittarius — and therefore my list omits them. But if you live where this part of the sky rises high enough to be seen well — south of latitude +45°, say — don't pass them up!

The Moon

This is the first object targeted by most observers — and who can blame them? It's a delight to follow the constantly changing face of the Moon as it sweeps from New to Full and back to New again. And even low-power binoculars, 6x35s for example, will reveal most of the larger craters when they lie near the terminator — the slowly moving line that divides lunar night from day.

In the first few evenings after New, the major feature you see on the crescent Moon is Mare Crisium, a dark oval patch near the middle. Mare Crisium, like all the other maria, is a broad expanse of lava that spilled out late in the Moon's early history.

Later, as the terminator progresses slowly westward toward First Quarter, the other maria on the Moon's eastern hemisphere — Fecunditatis, Nectaris, Tranquilitatis, and Serenitatis — become prominent in their turn.

Your best views will be from roughly three days before First Quarter to three days after. This is the period when the great craters such as Theophilus, Ptolemaeus, Alphonsus, Clavius, and Copernicus are visible on or near the terminator. This is also the best time to spot the curving scarp of the Apennine Mountains, which form the southeastern boundary of Mare Imbrium.

As the phase nears Full, watch the light-colored streaky rays from the craters Tycho and Copernicus develop and spread. Tycho's rays are by far the brighter and more impressive; Copernicus's rays are dimmer and shorter. After Full, the evening terminator will bring out the surface relief again as it advances westward. The ray systems fade and topography comes into prominence once more.

Mercury

Since Mercury never strays, or elongates, very far from the Sun in the sky, it's not surprising that many people have never seen the innermost planet. On page 89 of last month's issue, you'll find a "locator diagram" showing Mercury's path in the morning sky for the current apparition.

Since Mercury moves quickly, its appearances are usually brief — a matter of a few weeks. Check Eye on the Sky or The Backyard Astronomer for details. When you find it, Mercury will appear as a pinkish, starlike object. You won't see a disk or surface features, but finding this elusive planet is its own reward.

The best apparitions for Mercury-watching are evening elongations in the spring and morning elongations in the fall. At these times, the ecliptic — the path in the sky the planets stay close to — angles steeply to the horizon near sunrise or sunset, and Mercury's elongation from the Sun becomes elevation in the twilight sky.

Before leaving the solar system, take a look at two of the outer planets, Uranus and Neptune. Like Mercury, they will also show only as tiny points of light. But binoculars and the directions in The Backyard Astronomer will help you find them, and it's interesting to look in on them now and then as they slowly trace their lonely paths in the outer reaches of the solar system.

Messier 103

Lying in a beautiful, star-strewn field less than 2° northwest of Delta (δ) Cassiopeiae, M-103 is a rather faint open cluster of stars. Through binoculars you'll see two or three individual stars and one brighter cluster member.

M-103's designation comes from the fact that it was #103 on a list of celestial objects published by the 18th century French comet-hunter Charles Messier. These objects looked like comets in the eyepiece of his small refracting telescope — but weren't. Today, the Messier list amounts to a roster of the finest deep-sky objects and is a favorite hunting ground for many observers.

NGC-663

Another of Cassiopeia's numerous star clusters, NGC-663 lies between Epsilon (ϵ) and Delta Cassiopeiae, near the 5.8 magnitude star 44 Cassiopeiae. It will show up as a faint nebulous patch of light. Depending on how transparent your sky is, and how steadily you hold your binoculars, you may glimpse individual stars in the group.

This cluster's designation comes from the *New General Catalogue*, a century-old compilation that lists some 7,800 clusters, nebulae, and galaxies, and which is still used (in revised form) by astronomers today.

Messier 33

The great spiral galaxy M-33 in Triangulum is notoriously difficult to find. Anyone who searches for it will soon feel the frustration of *knowing* that you are looking right at it, but still can't quite see it. Oddly enough, a telescope is probably the worst instrument to use. Binoculars — with their low magnification and wide field of view — usually work far better.

I have seen M-33 as a large, very faint patch of light, with no evidence of the spiral arms that characterize it. To find it, you'll need exceptionally clear and dark skies, so save this object for a trip into the country.

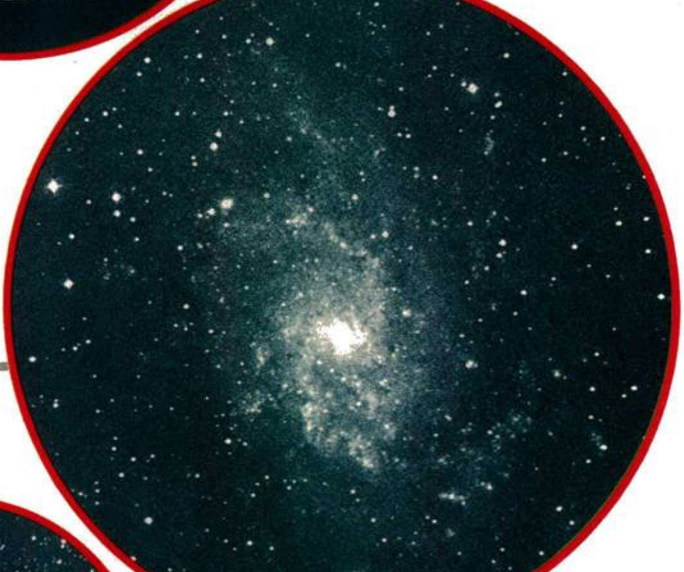
The Double Cluster, NGC-869 and NGC-884

Faintly visible to the naked eye as a little knot of light between the "W" of Cassiopeia and the spray of stars that marks Perseus, the Double Cluster is a fine showpiece in any instrument. Because it lies in the middle of the Milky Way, the cluster reveals a seemingly endless surrounding field of stars when viewed through binoculars. This is one of those objects that slowly reveals more and more stars as you gaze at it, so take your time and enjoy. Although you can pick out the Double Cluster even from light-polluted urban areas, your best views will come when you get away from city lights.

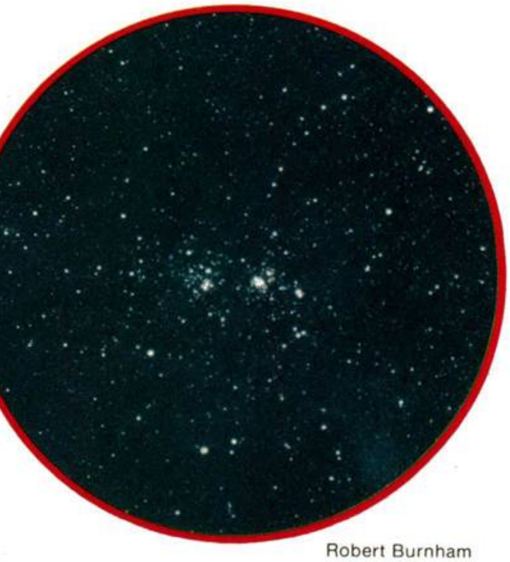
Messier 34

Scanning farther along the Milky Way into the constellation of Perseus, we find several more interesting objects, among them the open cluster M-34. This cluster contains around 80

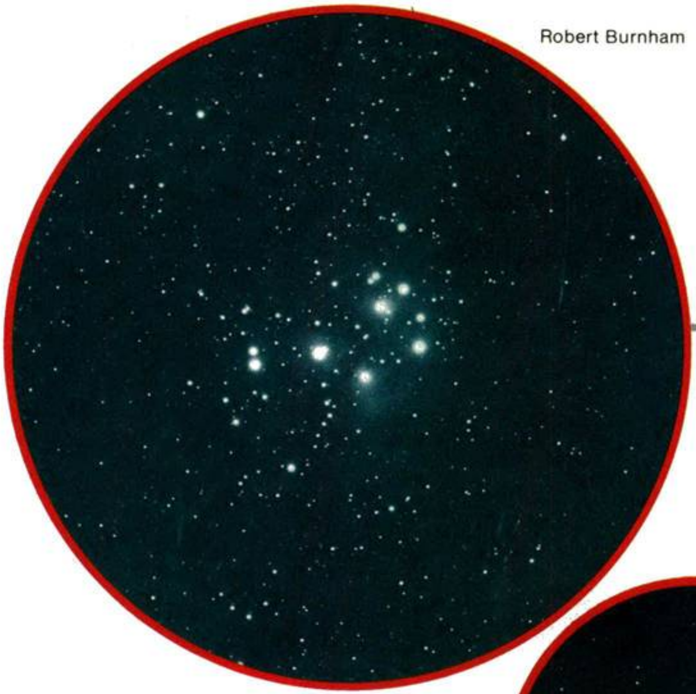
Lee Coombs


Jack Newton

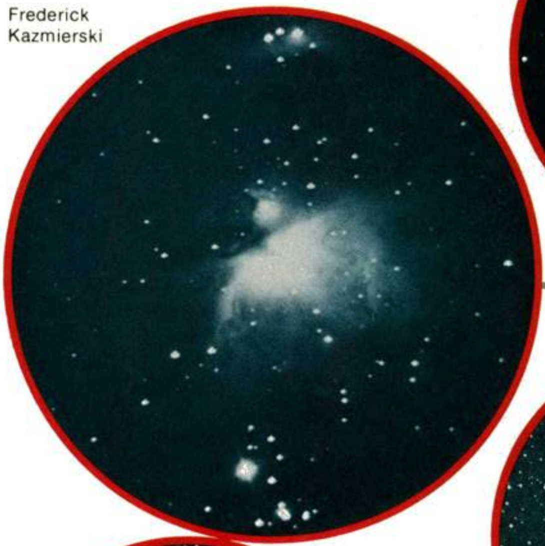
Jack Newton

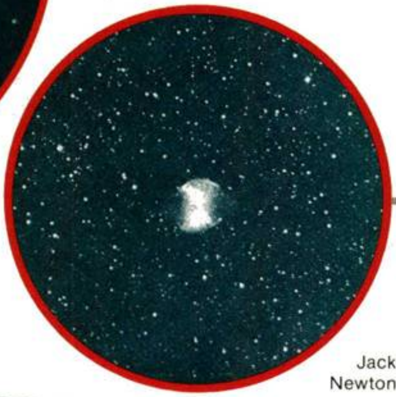

Robert Burnham

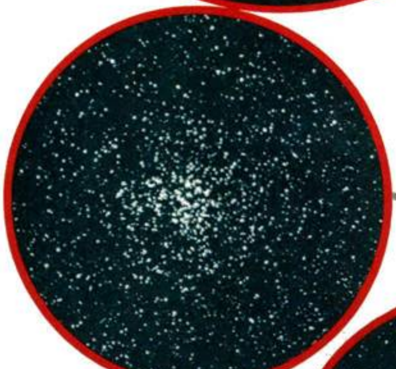
Lee Coombs


Robert Burnham

Jay Anderson


Frederick Kazmierski


Jack Newton


Jack Newton (M-37)

Jack Newton

stars and is quite conspicuous in binoculars. It spreads over an area of sky about equal to that of the Moon, but the stars in the center are substantially more clumped. Thus, you may discern only the central regions. With a pair of 10x50s, I have resolved five or six individual stars — although with better seeing conditions, you ought to see a few more.

The Pleiades, Messier 45

On clear nights from fall through spring, the naked-eye can make out a small group of stars to the northwest of Aldebaran, the bright red star in Taurus. Average eyesight will usually show six stars in this cluster, though some observers claim to have seen as many as 20.

Through your binoculars, many more of these stars will pop into view, and the entire cluster presents a truly splendid spectacle. Although photographs show the Pleiades are embedded in a dusty nebulosity, I have never seen this in my binoculars. Other observers *have* reported seeing it, though, so be sure to look very carefully whenever your sky is extremely dark and transparent.

As with other similar objects having large apparent diameters, the Pleiades are best seen with a wide field of view — which makes binoculars ideal for them. When I spy this cluster creeping up over the eastern horizon late on a summer evening, it always reminds me that winter is just around the corner.

The Orion Nebula, Messier 42

Situated below the Belt of Orion, M-42 is a grand sight with any kind of optical aid. Many who have seen it with telescopes call it the most spectacular deep-sky object in the entire heavens.

The naked eye sees a very indistinct "something" at its location, while binoculars — together with good seeing conditions — will reveal a small shining cloud of interstellar gas. You can make out M-42 from the city, but once again, rural skies are best.

M-42's companion nebula, M-43, lies nearby, but is much fainter (magnitude 9.1). I have never seen it in binoculars.

Messier 36, 37, and 38

These form a splendid trio of open clusters stretched across the Milky Way in Auriga. The westernmost is M-38, and although it contains roughly 100 suns, this 7th magnitude object is the faintest of the three. It is still a worthwhile object, though, and lies in an attractive field of stars.

M-36 is brighter, though it consists of but 60 stars. M-37 is the brightest and largest of the three, having a *population of some* 150 stars. All three clusters present a magnificent view when seen through binoculars, and, as with any rich area of stars, long and steady observation brings more and more of the fainter members into view.

deep-sky objects

Object	R.A. (2000) Dec.		Constellation	Mag.	Angular Size	Type
M-103	1h33m	+60°42′	Cassiopeia	6.8	6′	cl
M-33	1h34m	+30°39′	Triangulum	5.8	83′x53′	gal
NGC-663	1h46m	+61°16′	Cassiopeia	7.1	12′	cl
NGC-869	2h19m	+57°09′	Perseus	4.1	30′	cl
NGC-884	2h22m	+57°07′	Perseus	4.7	30′	cl
M-34	2h42m	+42°47′	Perseus	6.0	30′	cl
M-45	3h47m	+24°07′	Taurus	1.5	82′	cl
M-38	5h27m	+35°51′	Auriga	6.7	20′	cl
M-36	5h35m	+34°09′	Auriga	6.1	15′	cl
M-42	5h35m	- 5°23′	Orion	4.0	60′	neb
M-37	5h52m	+32°34′	Auriga	6.1	24′	cl
M-35	6h09m	+24°19′	Gemini	6.0	29′	cl
M-44	8h40m	+19°41′	Cancer	5.2	90′	cl
M-13	16h42m	+36°27′	Hercules	5.9	23′	cl
M-11	18h51m	- 6°16′	Scutum	6.3	12′	cl
M-71	19h54m	+18°47′	Sagitta	8.3	6′	cl
M-27	20h00m	+22°43′	Vulpecula	7.6	4′x8′	neb
M-29	20h24m	+38°31′	Cygnus	9.1	7′	cl
M-39	21h32m	+48°26′	Cygnus	5.1	32′	cl
M-52	23h24m	+61°36′	Cassiopeia	7.3	13′	cl

Messier 35

An open star cluster of around 120 stars, M-35 can be seen clearly — even by the unaided eye under good conditions — about 3° to the northwest of the third magnitude star Eta (η) Geminorum. Visible to the naked eye as a faint nebulous patch, M-35 should reveal a few member-stars when observed in binoculars.

There is a much smaller, fainter and more distant cluster NGC-2158 about 30′ of arc to the southwest, but this is "telescope material."

The Beehive, Messier 44

Although the overall magnitude of this loose open cluster is a fairly bright 4.5, M-44 still is only barely resolvable into stars by eye — and this calls for excellent vision and sky conditions. In 1609 or 1610, Galileo turned his crude, low-power telescope on it and discovered that this hazy spot, known since antiquity, was really a cluster of stars.

As with the Pleiades, this is an object that shows up best with low-powers and wide fields. But it's a bit elusive: any trace of cloud will hide the group, and the ancients regarded it as a sign of rain when this happened.

Messier 13

Well-known to telescope owners as the Great Globular Cluster in Hercules, M-13 doesn't usually appear on lists of binocular objects — but I include it anyway, because it's the most spectacular object of its kind visible from mid-northern latitudes.

M-13 was discovered in 1714 by Edmond Halley who described it as visible to the naked eye "... when the sky is serene and the Moon absent." A firmly-mounted pair of binoculars and careful observation should allow you to resolve its outlying member-stars.

The "Wild Duck" Cluster, Messier 11

This tightly-gathered cluster appears as a bright nebulous patch of light in a field of surrounding stars. To the east of it lies a beautiful circlet of stars comprised of 14, 15, Lambda (λ), and 12 Aquilae, and Eta (η) Scuti. To the west you can see a pair of double stars.

As far as the cluster itself is concerned, I have never been able to resolve any individual stars in it with binoculars: it always looks like a soft glow. M-11 picked up its nickname when one 19th century observer described the cluster's V-shape in his eyepiece as resembling "a flight of wild ducks"; this description is borne out when you view it with medium telescopic powers.

Messier 71

Located less then 2° southwest of the third magnitude star Gamma (γ) Sagittae, M-71 has been called both a globular and an open cluster. Through 10x50s, I find it very faint. Often, I've had to use "averted vision," an old observer's trick of looking slightly to one side of where you know a dim object is. Your eye's retina is more sensitive to light there and will pick up dim objects that are invisible when viewed directly. M-71 presents something of a challenge to the binocular observer; you should be pleased simply to locate it.

The Dumbbell Nebula, Messier 27

The Dumbbell lies just to the south of the 5th magnitude star 14 Vulpeculae. It also lies some 4° almost due north of Gamma Sagittae. Situated in an attractive field, it is moderately faint (magnitude 7.6) — but binoculars will reveal it as a small, elongated patch of light.

You'll need a telescope to see the shape from which this object takes its name, but spotting the Dumbbell with even medium-power binoculars will make the search worthwhile.

Messier 29

Composed of about 20 stars, Messier 29 is situated just to the west of the star 40 Cygni. I find it to be fairly conspicuous, with two or three individual stars resolved. M-29 lies in the Milky Way in Cygnus, so by scanning through here you'll also find other wonderful sights.

Since the group is relatively sparse, the low-magnification views in binoculars are often better than the high-power, small-field views a telescope affords.

Messier 39

Located a little to the west of 2 Cygni, M-39 contains around 25 stars, quite a few of which are resolvable through binoculars; its overall shape is that of a triangle. M-39 — together with the marvelous star field it lies in — is a must.

Messier 52

Found just to the south of 4 Cassiopeiae, M-52 is a moderately prominent object. To me, it looks like a bright nebulous patch with no individual stars visible. Despite this, it stands out well from the Milky Way background it resides in — perhaps because of the many stars it contains.

*****

Although no one will deny the eventual necessity of your owning a telescope if you want to do much observational astronomy, it would be equally foolish to deny the usefulness of binoculars. Many a household that lacks a telescope will nevertheless have a pair of binoculars. Take this list as your starting point; with a little careful looking, you'll soon be compiling your own list of favorites.

Brian Jones is an English amateur astronomer who has been observing for more than 20 years. His main interests are with deep-sky objects and meteors.

the backyard astronomer

andromeda

Mercury

Mercury will be briefly visible low in the morning sky before sunrise as its current apparition winds toward an end. After about the 4th or 5th of the month, it will be too close to the Sun to be seen. Superior conjunction comes on November 19.

But before this happens, there will be a fine conjunction between Mercury and Saturn on November 1. The exact moment of conjunction will be 5:50 UT — before the pair rises for North American observers. The separation between them will be only 40′ of arc. Although we will be observing them after conjunction, the view will still be very good — weather permitting, of course!

Mercury will lie to the south of Saturn, and will be both smaller and brighter, with a magnitude of -0.9 and a disk 5.3″ of arc across. Saturn's ball will be 15.6″ across (the rings spread 35.1″) and its brightness will be +0.9. Saturn will appear fully illuminated, but Mercury's 92% lit disk will show a distinct, if slight, gibbous phase.

Since both planets lie close to the Sun in the sky — about 11° away — you'll have only a short time to see them before the sky becomes too bright. Plan accordingly: set your scope up where you have a good view to the east-southeast and little or no horizon clutter to contend with.

If you miss it, try again the following morning. Although Mercury and Saturn won't be as close as they were on the 1st, they'll both be within the field of view of a low-power eyepiece.

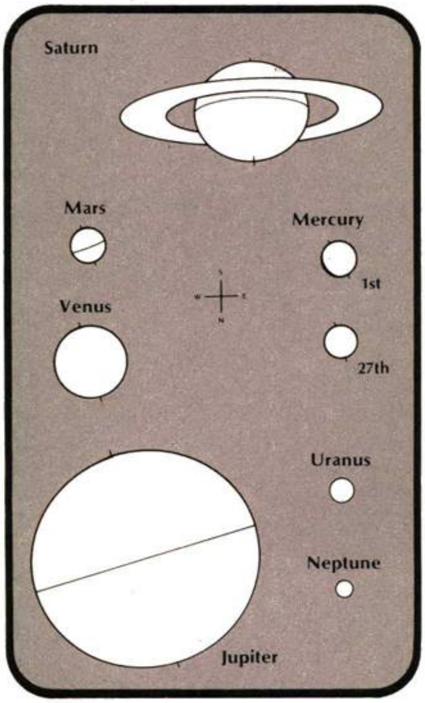
Venus

Venus lies too close to the Sun for telescopic observation this month; superior conjunction comes on November 4.

The early morning Sun slants across Copernicus, leaving its floor in darkness — while to the east, under a higher Sun, Eratosthenes displays a complex central peak. Brian Tkachyk used an 8-inch Schmidt-Cassegrain, 100 ASA film, and a 2-second exposure at f/60 to win this month's "Best Astro-Photo" award.

Mars

Though it still remains low in the southwestern sky after sunset, Mars' visibility has been increasing slightly since October. The reason for this is that its course along the ecliptic has finally "bottomed out" and the planet is now moving toward higher declinations. In addition, as sunset comes earlier each day, darkness reveals the planet a little sooner each night. Despite this, Mars is still small and distant, and it's hard to discern much on its disk — even with a large telescope and high powers.



On the 19th, the Moon will occult Mars as seen from the southern parts of the U.S. The northern limit of the occultation runs southwest from the east coast near Richmond, Virginia, to Shreveport, Louisiana. From there, the path swings west to the Dallas-Ft. Worth area in Texas. The path then turns northwesterly and runs until it crosses the west coast near Coos Bay, Oregon.

Unfortunately, only the observers on the eastern seaboard will see the occultation in a relatively dark sky; farther west, daylight will still be bright. From locations north of the occultation limit, the Moon will appear to pass to the south of Mars.

Mars will display a 5.1″ of arc disk, look slightly gibbous, and shine at magnitude +1.2. The Moon's age will be about 4 days and earthlight on the unilluminated part will lend a strongly three-dimensional effect to its appearance. This will be one of the year's best celestial events — don't miss it!

Asteroids

1 Ceres (magnitude 8.7) lies in southern Ophiuchus. Its positions:

9th: 17h 06m 09s, -23° 56.9′
19th: 17h 23m 17s, -24° 31.0′

Ceres will be in conjunction with the Sun on December 29, and sets around 6 p.m. local time on November 15.

2 Pallas is in conjunction with the Sun on November 26, and is too close to it to be seen all month.

3 Juno (10.9) is moving eastward in southeastern Scutum. Its positions:

9th: 18h 41m 04s, -13° 58.4′
19th: 18h 54m 56s, -14° 12.0′

Juno sets about 7:30 p.m. local time at mid-month.

4 Vesta (7.7) is in Capricornus. Its positions:

9th: 21h 32m 53s, -21° 51.2′
19th: 21h 44m 42s, -20° 40.3′

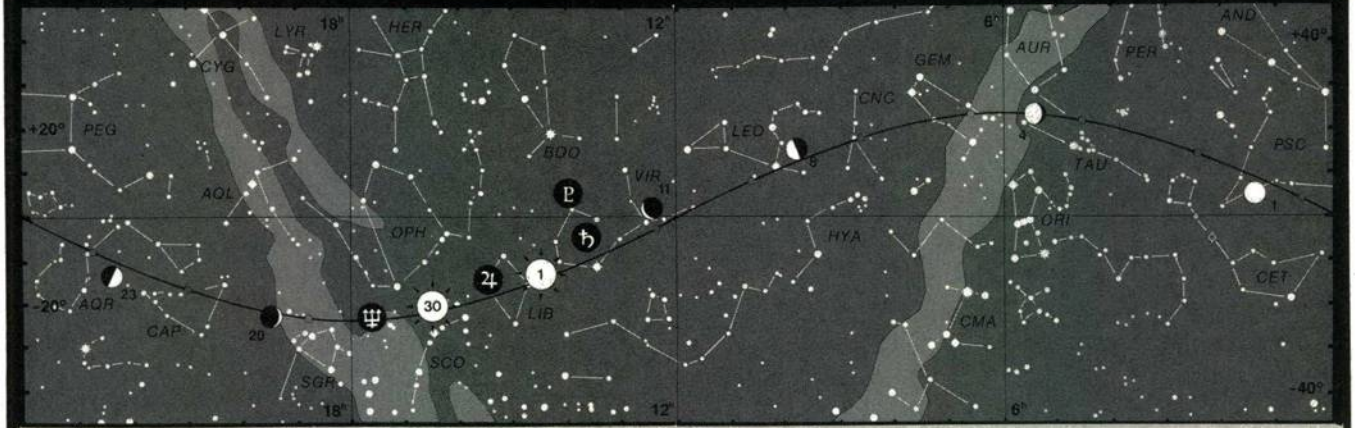
Vesta sets around 11:30 p.m. local time on the 15th of the month.

To facilitate plotting their positions on a star atlas, all asteroid coordinates are for the epoch 2000.0.

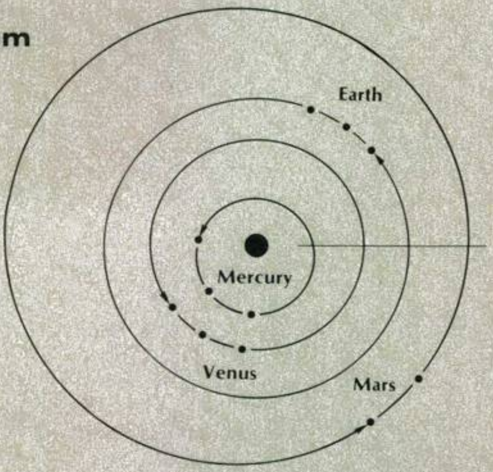
Jupiter

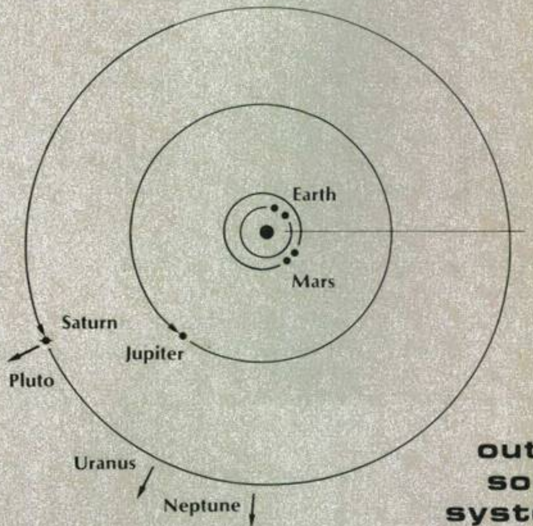
Jupiter will be too close to the Sun to be seen during November. It is in

planetary data november 1982


LYR
18h
HER
12h
6h
AND
+40°
CYG
AUR
PER
GEM
CNC
+20°
PEG
LEO
8
4
BOO
TAU
PSC
VIR
11
AQL
ORI
1
OPH
HYA
CET
23
1
-20°
AQR
30
LIB
CAP
20
CMA
SCO
SGR
18h
12h
6h
-40°

inner solar system


Earth
Mercury
Venus
Mars


Earth
Mars
Saturn
Jupiter
Pluto
Uranus
Neptune

outer solar system

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (1982.9)	Dec
Sun		1	-26.8	32.3′	—	0.99	—	—	218°14.7′	14h 23.4m	-14°15.2′
		15	-26.8	32.4′	—	0.99	—	—	232°17.9′	15h 19.5m	-18°20.6′
		30	-26.8	32.5′	—	0.99	—	—	247°27.3′	16h 22.6m	-21°33.2′
Mercury	☿	1	-0.9	5.2″	92%	1.30	0.38	174°52.8′	206°12.0′	13h 41.2m	-8°43.8′
		15	-0.9	4.7″	100%	1.43	0.45	223°20.3′	229°02.6′	15h 08.4m	-17°25.7′
		30	-0.7	4.7″	99%	1.44	0.47	265°24.4′	252°42.6′	16h 46.2m	-23°44.8′
Venus	♀	10	-3.5	9.8″	100%	1.71	0.72	230°48.3′	228°18.2′	15h 05.9m	-16°48.1′
		30	-3.4	9.9″	99%	1.70	0.73	262°36.9′	253°25.2′	16h 49.9m	-22°37.1′
Mars	♂	15	+1.2	5.1″	92%	1.84	1.39	312°38.8′	280°07.3′	18h 46.4m	-24°24.4′
Jupiter	♃	15	-1.2	30.8″	100%	6.39	5.40	230°59.6′	229°38.0′	15h 15.9m	-17°14.9′
Saturn	♄	15	+0.9	15.7″	100%	10.62	9.73	206°03.4′	207°22.4′	13h 48.8m	-8°47.0′
Uranus	⛢	15	+6.0	3.5″	100%	19.88	18.91	244°44.9′	243°40.9′	16h 08.6m	-20°51.4′
Neptune	♆	15	+7.8	2.4″	100%	31.09	30.27	266°34.2′	265°06.7′	17h 40.7m	-22°08.8′
Pluto	♇	15	+13.9	0.1″	100%	30.80	29.92	207°03.3′	207°22.7′	14h 07.0m	+4°44.7′

moon data

Full Moon .... November 1 at 12:57
Last Quarter .... November 8 at 6:38
New Moon .... November 15 at 15:10
First Quarter .... November 23 at 20:06
Full Moon .... December 1 at 00:21
Last Quarter .... December 7 at 15:53
Perigee: November 4 at 10h . . 365,466 km
Apogee: November 20 at 11h . 405,367 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times in The Backyard Astronomer are UT unless otherwise noted. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on February 2, then EST for the event is 10 p.m., February 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m., March 4.

The July 20, 1982 partial solar eclipse, which was visible in the Arctic and western Europe, came two weeks after the July 6 lunar eclipse. Claude Rieder photographed it at sunset from the Ile d'Oleron off the west coast of France. He used 200 ASA film and a 135mm lens with a 2x teleconverter.

conjunction with the Sun on the 13th.

Saturn

Saturn's emergence from the glare of the Sun during November will be relatively swift. On the 1st (the date of its conjunction with Mercury), it will be only about 3° high 45 minutes before sunrise. By month's end, it will be 25° high — far enough above the horizon for you to begin your saturnian observations again.

Uranus

Uranus, like Venus, Pallas, and Jupiter, will be too near the Sun for easy sighting this month. It reaches conjunction on the 27th.

Neptune

November will be your last chance to observe Neptune — it reaches conjunction with the Sun on December 19. Look for it now about a degree southwest of the star 58 Ophiuchi. The planet will be recognizable by its perceptible disk and slow day-to-day motion.

Meteors

November is Leonid month — and while this year's return will probably match the lackluster display of most years, there's always a chance for something a lot more spectacular (see AstroNews, page 68 this issue).

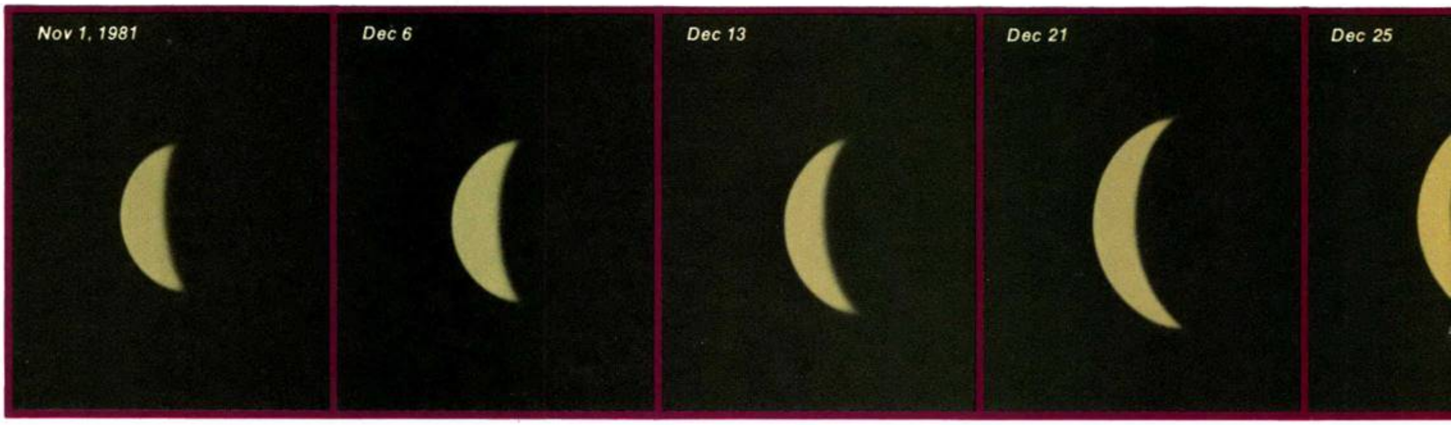
The date of peak activity is the 17th. Although the Moon's phase will be favorable (shortly after New), the predicted time of maximum unfortunately comes during daylight for North America. Try looking on the nights of the 16th-17th and 17th-18th, and hope for the best.

But not all the meteors of November belong to the Leonids. On the 5th and 14th, two lesser showers peak: the Taurids and the Andromedids, respectively. The Taurids appear to come from the general Pleiades/Hyades area and average about 5 to 10 per hour. The Andromedids' radiant lies near Gamma (γ) Andromedae. This shower, like the Taurid, produces some 5 to 10 meteors per hour.

The Last Quarter Moon will interfere for the Taurids, but the Andromedids will enjoy a New Moon and a dark sky.

close-up on andromeda

Andromeda, the chained maiden, hovers near the zenith on November evenings and graces the autumn sky



Above: Jean Dragesco made this series recording the changing size and phases of Venus with 2415 Technical Pan film, a 14-inch Schmidt-Cassegrain, and 1/4-second exposures at f/60. Right: NGC-2264 is a cluster of stars embedded in a bluish nebulosity near the star 15 Monocerotis. Photo by Evered Kreimer.

with her beautiful arcs of stars that diverge from Alpheratz. Stretched eastward from the Great Square of Pegasus, lie four other stars — three of second magnitude. These five points, in the words of William T. Olcott, "are strung out along the eastern sky like pendant lamps, and present a charming appearance."

The pattern of Andromeda is prominent from northerly latitudes. She is the attractive center of the autumn sky and lures backyard stargazers with a promise of heavenly wonders. Above the figure lies her mother, Cassiopeia, and between the two you'll notice the intriguing Y-shaped asterism called **Frederick's Glory** — a fine binocular sight.

To locate Andromeda, face southeast and fix your gaze on the upper left corner of the Great Square. From this star, Alpheratz, you'll easily note the line formed by **Mirach** and **Almach** — the lower curve of Andromeda. Once you've followed this line, it's easy to discern the upper curve, although those stars are fainter.

Alpha (α) Andromedae, or **Alpheratz**, comes from Arabic, and means "the head of the woman in chains." It is a second magnitude type B8 star that lies 120 light-years away. An 11th magnitude optical companion is in the same low-power field.

Beta (β) Andromedae, or **Mirach**, also shines at 2nd magnitude, and has a 14th magnitude companion that E.E. Barnard discovered with the Yerkes 40-inch refractor in 1898. Unless you have a large scope, the companion will elude your efforts. Just 6.4′ to the northwest you'll spot the 11th magnitude galaxy **NGC-404**, a fuzzy elliptical blob that's a good test of your scope's light-gathering ability.

Gamma (γ) Andromedae, **Almach**, marks the endpoint of the lower curve, and is a double that contains a 2.1 magnitude Type K3 primary with a 5th magnitude companion. The color contrast of this pair is striking — golden yellow and blue-green. Its double nature, first discovered in 1788, led astronomers to conclude the system is a quadruple group. The A and B components are separated by 10 arc-seconds at a position angle of 65°.

Otto Struve observed the B component as a close binary with an orbital period of 60 years. 1982 marks the year of largest separation since 1951 — 0.6 arc-second, making B's 6.3 magnitude companion a severe test of observer and instrument. In splitting close doubles, T.W. Webb commented that "it is important to know the difference between one elongated disk crossed by a dark interference line which is sometimes called division (partial resolution), and two round disks with black sky between them." In other words, carefully study the image in your eyepiece to be sure your scope has achieved complete resolution. Don't fudge on your observations; you'll know if your instrument resolved the pair or not.

To split the B and C pair you'll need at least an 8-inch, a trained eye, and superb seeing conditions. Sometimes even 12-inchers fail this resolving test, yet some observers have split the pair with four and five-inch scopes on nights of perfect seeing.

Point your scope 5° south and slightly west of Gamma, and in your finder you'll notice the large, loose open cluster **NGC-752** almost touching the binocular double **56 Andromedae**. Nearly 80 stars are packed into a 7th magnitude ball 45 minutes across. Webb described this cluster as a "wide, rich region especially of small stars; curious groupings here and there." Burnham considered the group a binocular object due to its low contrast and wide scattering. A 6-inch at 50 power reveals many doubles within the cluster, and at lower powers 56 And remains in the same field.

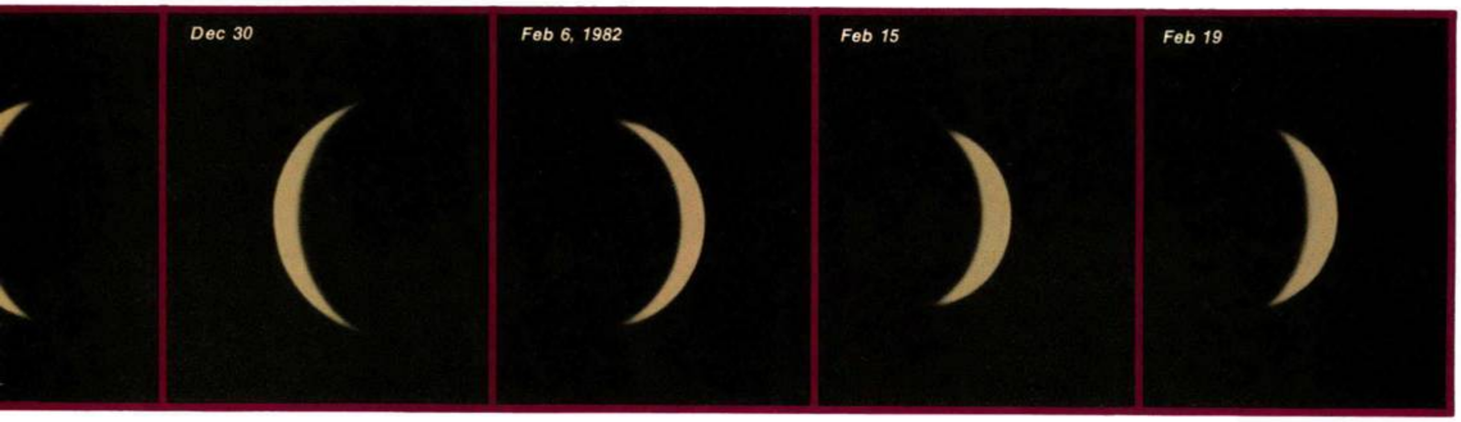
From NGC-752, sweep west and a little south, passing over Beta, until you reach the double star **Pi** (π). This system has a 4.4 magnitude primary (itself a spectroscopic binary) and an 8.7 magnitude companion, situated 36″ of arc away to the south.

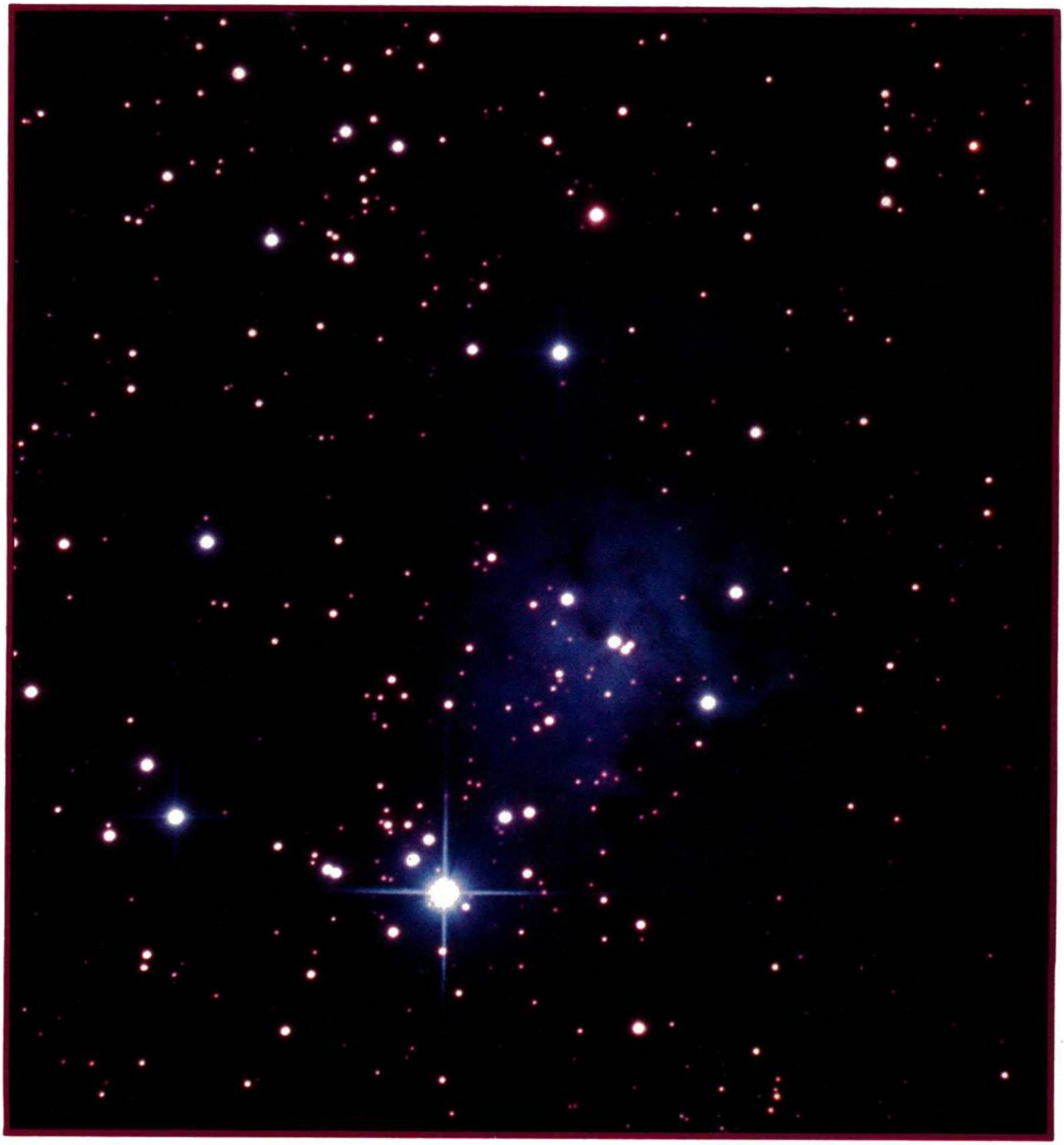
If you have a small scope and haven't logged many planetary nebulae in your observing notebook, find **NGC-7662**, a 9th magnitude blue-green disk 32 x 28 seconds in size. NGC-7662 was discovered by Sir William Herschel, and it is an easy object for a three-inch at 30x. Although big scopes will show more, *don't be deterred if you only have a small instrument*. The field that surrounds NGC-7662 contains several stars that provide a good reference for attaining perfect focus. After you've critically focused on a field star, move back to the nebulae and study it carefully.

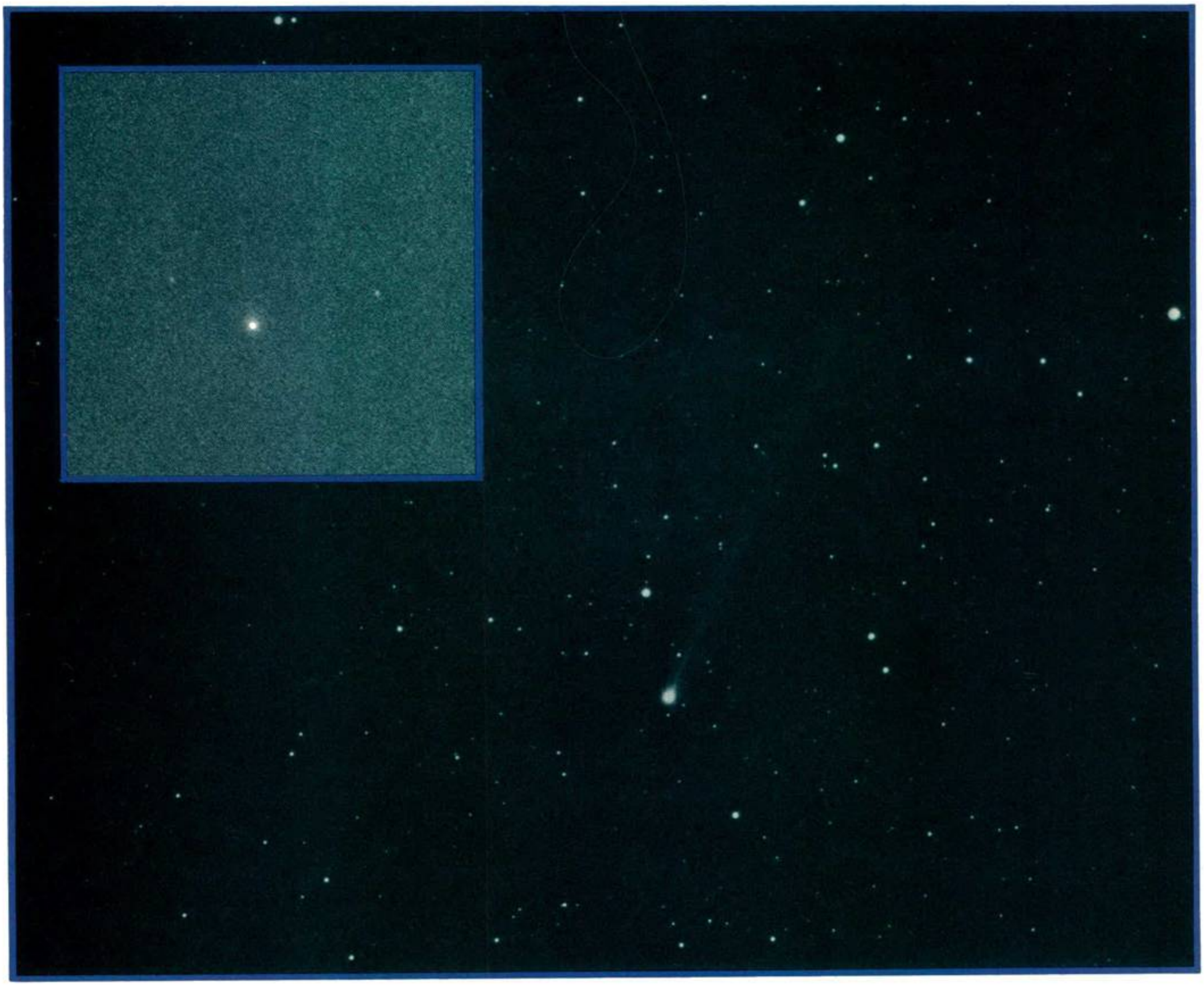
Depending on the seeing conditions, scopes of 8-inch or larger aperture reveal a doughnut-disk and possibly a central star. E.E. Barnard described his view of NGC-7662 through the Yerkes 40-inch: "a beautiful object — a slighty elliptical disk with quite sharply defined outlines. Unsymmetrically placed on this is a roughly elliptical broken ring of greater brilliance. The interior of the ring is dark, but not black, and in this, approximately centered, is a faint stellar nucleus."

From small objects only a few arc seconds in diameter, you can move to a well-extended deep-sky wonder. The showpiece of the constellation, and the season, is the **Great Andromeda Galaxy** — Messier 31.

We've now left the realm of our galaxy, and ventured 2.2 million light-years across deep space to one of our nearest galactic neighbors. Even from our distance, the Andromeda Galaxy is a naked eye object, attesting to its prodigious light output. You can spot M-31 as a fuzzy spike on the upper curve of Andromeda, floating just above 4th magnitude **Nu** (ν) **Andromedae**. In a dark sky you'll notice it immediately as a light ray hovering on the threshold of sight, and


Dec 30
Feb 6, 1982
Feb 15
Feb 19





The first photos of Comet Austin (1982g) were trickling in just as we went to press. Above left: Gerry Samolyk photographed it on August 18 with the Milwaukee Astronomical Society's 12-inch Newtonian. Above right: Michael Haigh of Cedar Falls, Iowa, photographed it on the 21st with a 5½-inch Schmidt camera.

with averted vision you can trace its length for several degrees.

First take a look at it with binoculars. What was a hazy needle becomes an amorphous blob of nebulous matter whose appearance is easily confused with diffuse nebulae within the Milky Way. It wasn't until the mid 1930s that astronomers deduced the true nature of this isolated "island universe." We now regard it as typical of many other spiral galaxies.

If you sweep slowly across the expanse of M-31 with binoculars or short-focus telescopes, you can detect its full size. Measuring 160 x 35 minutes, its combined light equals that of a 4th magnitude star. The galaxy fills a space in your eyepiece as big as 10 Full Moons side by side! The bright nucleus, unresolved in even large telescopes, appears as a pinpoint condensation of star-stuff surrounded by glowing clouds and spiral arms.

In an 8 or 10-inch you can resolve some dark lanes within the galaxy, and also discern a hint of its spiral structure. According to Robert Burnham, Jr., "early observers thought this 'nebula' was composed of glowing gases; some regarded it as a solar system in the making, or an accretion of material into a proto-stellar source."

It wasn't until the discovery of Cepheid variable stars within M-31 that astronomers calculated its immense distance. In 1923 Edwin Hubble definitely established M-31 as an extra-galactic object, lying at a distance then thought to be 900,000 light-years. In later years, a more accurate understanding of Cepheids pushed the distance figure to 2.2 million light-years — where it stands today.

The region surrounding M-31 contains four other galaxies. The two companions of the Great Galaxy are easy objects for small telescopes. **M-32** is a binocular object, and although listed as 8th magnitude, it seems brighter and is obvious when you search the expanse of the main galaxy with field glasses. **NGC-205** is a larger but dimmer elliptical blob situated 35′ to the northwest of the main nucleus.

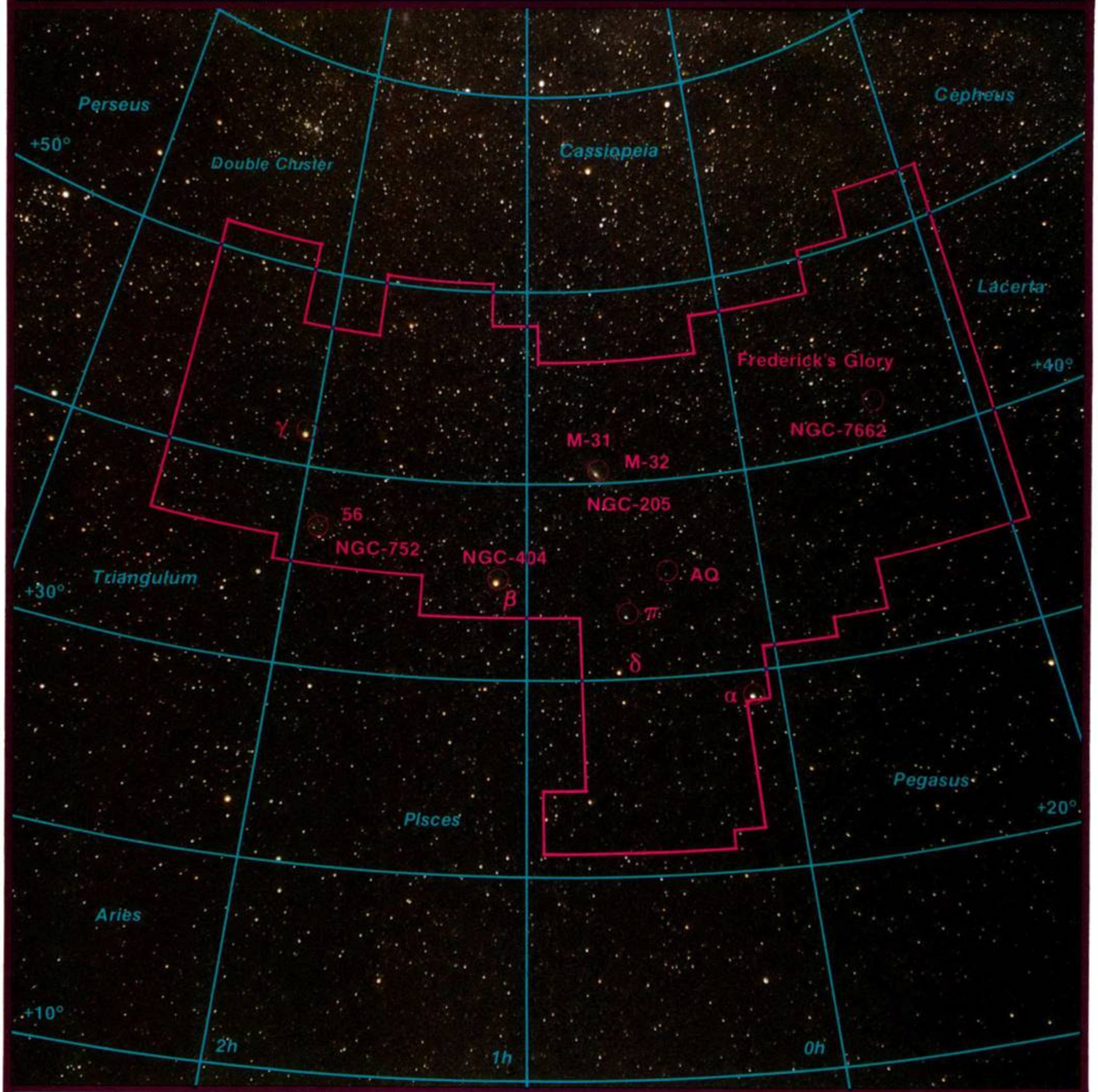
Two smaller and fainter galaxies lie 7° to the north. You'll need a 6-inch to view **NGC-185** and **NGC-147**, but they both will fall in the same low-power field. These two small companions are really in the constellation Cassiopeia (and were mentioned in Close-up last month), but are gravitationally associated with M-31 in the same way that the Magellanic Clouds are associated with the Milky Way.

When searching for this family of star systems, first allow your eyes time to dark-adapt, then identify M-31 visually and trace its expanse as far as you can. If you have binoculars, see what they will show of this distant island universe, then finally turn your telescope on this celestial wonder. By gradually increasing light-gathering power and magnification, and with fully dark-adapted eyes, you'll see more than you think, and the quality of your observations will improve.

Photo by Robert Provin and Brad Wallis

andromeda

Map by Robert Burnham


Perseus
+50°
Double Cluster
Cassiopeia
Cepheus
Lacerta
Frederick's Glory
+40°
NGC-7662
γ
M-31
M-32
NGC-205
56
NGC-752
NGC-404
AQ
Triangulum
+30°
β
π
δ
α
Pegasus
+20°
Pisces
Aries
+10°
2h
1h
0h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (2000)	Dec.
Alpha (α)	★	2.1	—	00h06m	+28°49′	00h08m	+29°05′
AQ	m★	6.9→8.2	332d	00h25m	+35°18′	00h28m	+35°36′
Pi (π)	★^{2}	4.4,8.7	36″	00h34m	+33°27′	00h37m	+33°43′
NGC-205	§0	8.2	8′x3′	00h38m	+41°25′	00h40m	+41°41′
M-31	§S	3.5	160′x35′	00h40m	+41°00′	00h43m	+41°16′
M-32	§0	8.2	4′x3′	00h40m	+40°36′	00h43m	+40°52′
NGC-404	§0	11.3	6′x6′	01h07m	+35°27′	01h09m	+35°43′
Beta (β)	★^{2}	2.0,14.0	28″	01h07m	+35°21′	01h10m	+35°37′
NGC-752	○	7.0	45′	01h55m	+37°25′	01h58m	+37°41′
56	★^{2}	5.7,5.8	17″	01h53m	+37°00′	01h56m	+37°15′
Gamma (γ)	★^{3}	2.1,5.1,6.3	10″,0.6″	02h01m	+42°06′	02h04m	+42°20′
NGC-7662	■	9.4	32″x28″	23h24m	+42°14′	23h26m	+42°28′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
m★	*Regular Variable*
n★	*Irregular Variable*
ℵ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

Travel Through Time and Space

with ASTRONOMY'S

SPACE 1983 CALENDAR

SPACE 1983
The Calendar of Space Art and Photographs from the Editors of ASTRONOMY Magazine
NASA

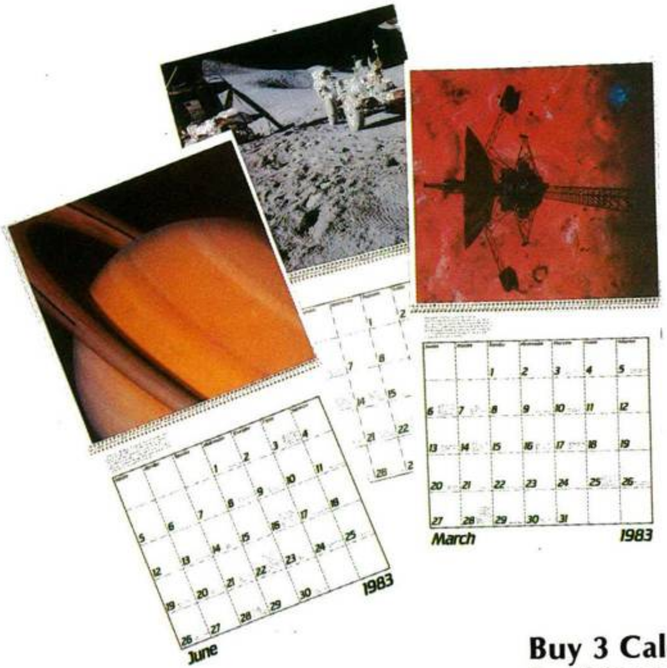
— Visit the Moon with the Apollo 15 astronauts

— Behold the beauty and intrigue of Saturn as Voyager 2 approaches the ringed giant

— Celebrate the magnificent launch of the Space Shuttle *Columbia*

— View the spectacle of Omega Centauri, one of the vast stellar clusters surrounding the Milky Way

— Follow a battered Voyager 2 on its journey out of the Solar System


March
1983
June
1983

- Exciting, detailed photos from NASA
- Paintings by today's finest space artists
- 13 colorful images suitable for framing, each 11½" x 11½"
- Spiral-bound for flat, easy hanging
- Notable dates in astronomy, celestial events and holidays

SPACE 1983 — an exciting journey through time and space

$6.95

Postage and handling included
Foreign orders add $1.50

**Buy 3 Calendars
for $19.95
Get a 4th FREE**

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

TELESCOPE OR TELEPHOTO?

THE C90 "SPOTTING SCOPE" (IT'S ALSO A 1000MM TELEPHOTO)

THE CELESTRON® C90 IS BOTH! AND MORE.

Can you imagine an affordable, ultra compact 3½" (90mm) diameter telescope that delivers incredibly sharp images and doubles as a 1000mm focal length telephoto? How about an astronomical telescope equipped with clock drive and setting circles with permanent optical collimation? Or, a variable power spotting scope that weighs only 3.5 lbs? You don't have to imagine any longer, the C90 offers all these features, and more!

Three C90 versions, the Telephoto, the Spotting Scope and the Astro Telescope can be used photographically or visually. How? Celestron engineered the C90 system to deliver high performance in a rugged, portable package with adequate back focus to accommodate cameras or eyepieces. Each C90 has hand-polished, Maksutov-Cassegrain, precision optics.

With a C90 you can view distant nebulae, the rings of Saturn or craters on the Moon. Attach a camera and you can photograph the night sky or objects on the ground as close as 10 feet!

Three C90's are available:

C90 TELEPHOTO: Standard Features: Black Finish, Carrying Case, T-Adapter, Lens Caps.
C90 SPOTTING SCOPE: (shown above) Standard Features: Orange & Brown Finish, 5 x 24 Finderscope, Lens Caps, 30mm & 18mm Oculars, Star Diagonal, Carrying Case.
C90 ASTRO TELESCOPE: Standard Features: Orange & Brown Finish, 5 x 24 Finderscope, Lens Caps, 30mm & 18mm Oculars, Star Diagonal, Carrying Case, Fork Mount, Setting Circles, Electric Clock Drive and Power Cord.

SUGGESTED BASIC PACKAGES

1. **TELEPHOTO PACKAGE**
   C90 Telephoto°, T-Ring, Celestron Photo Tripod, Tele-Converter, Skylight Filter = 1

°To use as a 40 power visual telescope, get a Porro Prism –.96" and a 25mm Ocular–.96"

2. **SPOTTING SCOPE PACKAGE**
   C90 Spotting Scope, Porro Prism–.96", T-Adapter–C90, T-Ring, Celestron Photo Tripod

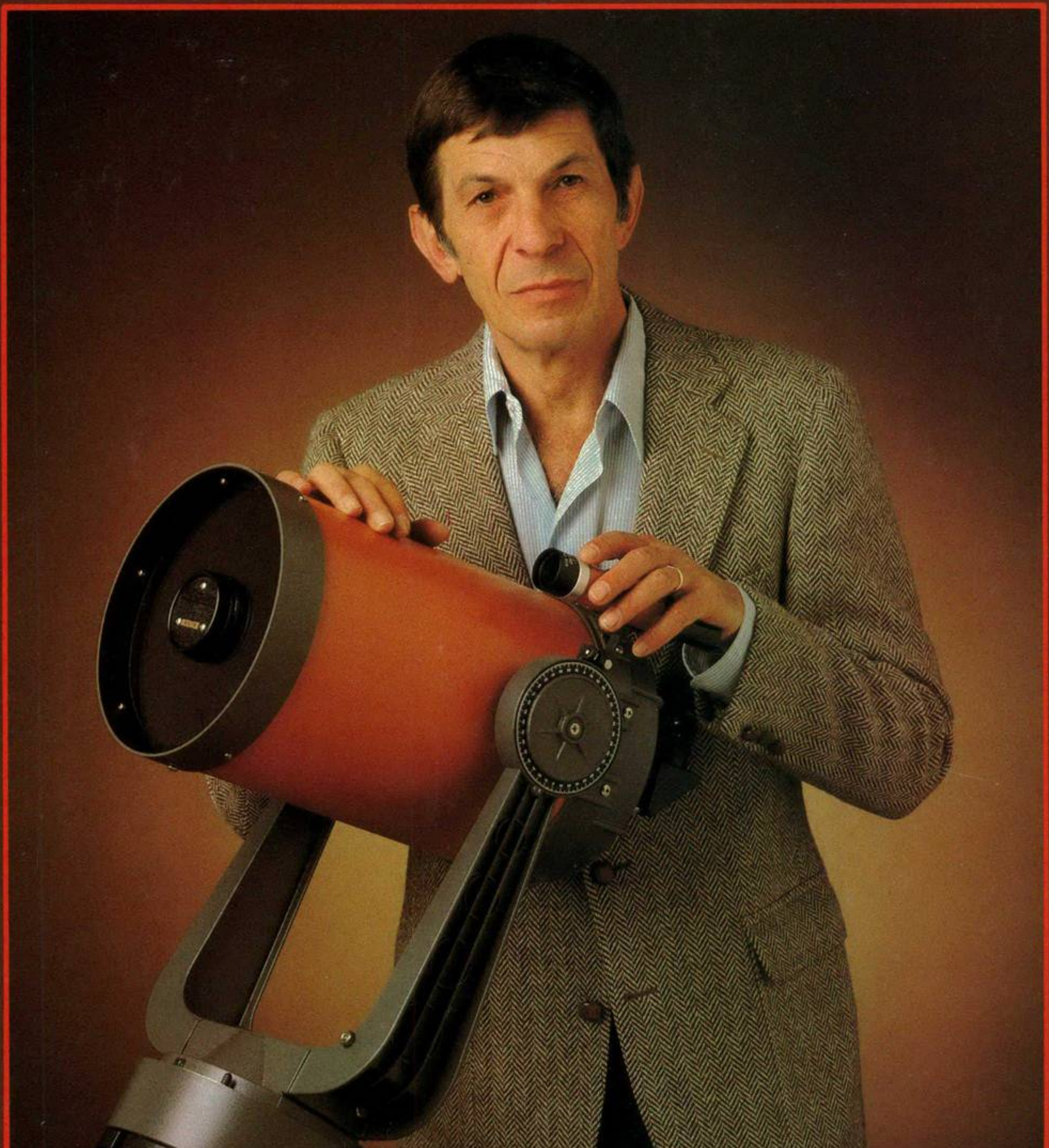
3. **ASTRO TELESCOPE PACKAGE**
   C90 Astro Telescope, Wedge–C90, Tripod–5/8/90, T-Adapter–C90, T-Ring, Porro Prism–.96"

CELESTRON® For *Adventure* in Astronomy

TOLL-FREE TELESCOPE INFORMATION SERVICE 1-800-421-1526 (within the Continental USA)

For C90 User's Manual send $1.00 to Celestron International, Box 3578-B, 2835 Columbia Street, Torrance, CA 90503

"When I Explore The Real Universe, I Use Precision Optics From Celestron®"



Leonard Nimoy and the Celestron C8 Telescope

TELESCOPES from CELESTRON®

for *Adventure* in Astronomy

Toll-Free Telescope Information Service
1-800-421-1526